Yellowstone Fisheries & Aquatic Sciences

Annual Report
2008

Geode Creek, a tributary of the Yellowstone River, is home to an introduced population of genetically unaltered westslope cutthroat trout.

Amphibian surveys on Yellowstone's Northern Range focused on the Blacktail Deer and Elk creek drainages.

Yellowstone National Park is home to the most ecologically and economically important inland cutthroat trout fisheries remaining in North America. However, threats to these native trout have, over the past decade, irreversibly altered and made future sustainability of this thriving and diverse ecosystem uncertain. Science has helped to develop our understanding of the consequences of status-quo management. In fact, without swift and continuing action, negative effects on the native trout populations of Yellowstone—keystone energy sources for numerous mammal and bird species, and a recreational focus for visitors—have the potential to produce impacts that will reverberate throughout the Greater Yellowstone Ecosystem.

For instance, each predatory, non-native lake trout—a species illegally introduced to Yellowstone Lake at least 20 years ago but not discovered until 1994—can annually consume at least 41 cutthroat trout each year. Lake trout have the potential to decimate the Yellowstone Lake cutthroat trout population in our lifetime without heightened and maintained management efforts. Lake trout are not an acceptable substitute for cutthroat trout in the ecosystem because they occupy an ecological niche unavailable to cutthroat-eating predators, threatening the many species, such as grizzly bears, bald eagles, and river otters, which depend on cutthroat trout for survival.

Albeit much more quietly, the brook, brown, and rainbow trout intentionally stocked by managers during the park's early history have also taken their toll on cutthroat trout populations across Yellowstone. The native westslope cutthroat trout of the Madison River, for example, a specialist species requiring pristine habitats, have been eliminated due to their inability to compete with aggressive, non-native trout. In addition, in many park waters the infusion of non-native-trout genetic material into stream-resident cutthroat populations by interbreeding among species has occurred and cannot easily be reversed. The loss to the cutthroat populations is permanent, and any recovery will be achieved only through direct intervention. The recent rainbow trout invasion of the upper Slough Creek meadows, and the resulting loss of that world-renowned fishery's genetic integrity, is an example of how serious this problem is.

The stakes are high, raising the bar for innovative management and fundraising. The increased magnitude of the problems faced by the park's fisheries, and the accelerated rate at which they are occurring, are straining Yellowstone's resources. Despite this, our hope and enthusiasm remain high. Within Yellowstone Lake, cutthroat are showing subtle signs of recovery, while lake trout are showing signs of suppression. Within the streams, momentum could not be greater as we continue our first cutthroat restoration project and the replication of newly discovered, pure-strain westslope cutthroat trout populations.

This annual report describes historic and continuing park aquatics programs with data and information obtained through 2008. In several instances, the report also outlines our vision for the program, with specific project goals and objectives for future years. This was done in an attempt to ensure program transparency; we want to make sure that everyone with an interest has a solid understanding of both our intent and the direction our efforts are taking to preserve and restore native fishes in the waters of this tremendous park.

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Yellowstone cutthroat trout

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Title page art courtesy Mimi Matsuda.

Front cover captions (left to right): Fisheries technician Brian Ertel with a spawning Yellowstone cutthroat trout at Clear Creek, a tributary to Yellowstone Lake (photo by Alexis Wolf). Fisheries technician Derek Rupert at the fish barrier on East Fork Specimen Creek (photo by Todd Koel). National Park Service fisheries technician Stuart Brown and Student Conservation Association volunteer Nick Bankston with record-sized lake trout caught from gillnets set on Yellowstone Lake (photo by Pat Bigelow).

Back cover captions (left to right): Fisheries technician Becky Adams prepares to dock the gillnetting boat, NPS Hammerhead (photo by Todd Koel). Aquatic ecologist Jeff Arnold and crew sample water at High Lake (photo by Joseph Skorupski). Montana Conservation Corps crew assisted in building a fish barrier in East Fork Specimen Creek (photo by Todd Koel).

Background: Moonlight on Yellowstone Lake (NPS photo by J. Schmidt, 1977).

Opposite page: Fisheries technician Joe Skorupski samples Yellowstone Lake.

Note: Native fishes shown out of water were not injured.

Contents

Background

When Yellowstone National Park was established in 1872, it was the only wildland under active federal management. Early visitors fished and hunted for subsistence, as there were almost no visitor services. Fishes were viewed as resources to be used by sport anglers and provide park visitors with fresh meals. Fish-eating wildlife, such as bears, ospreys, otters, and pelicans, were regarded as a nuisance, and many were destroyed as a result (Varley and Schullery 1998).

To supplement fishing and counteract "destructive" consumption by wildlife, a fish "planting" program was established. Early park superintendents noted the vast fishless waters of the park and asked the U.S. Fish Commission to "see that all waters are stocked so that the pleasure seeker can enjoy fine fishing within a few rods of any hotel or camp" (Boutelle 1889). The first fishes from outside the park were planted in 1889–1890, and included brook trout (*Salvelinus fontinalis*) in the upper Firehole River, rainbow trout (*Oncorhynchus mykiss*) in the upper Gibbon River, and brown trout (*Salmo trutta*) and lake trout (*Salvelinus namaycush*) in Lewis and Shoshone lakes (Varley 1981). The harvest-oriented fish management program accounted for the planting of more than 310 million native and nonnative fish in Yellowstone between 1881 and 1955. In addition, from 1889 to 1956, 818 million eggs were stripped from the cutthroat trout of Yellowstone Lake and shipped to locations throughout the United States (Varley 1979).


YELL–34659

Mammoth Hot Springs Hotel bellmen display their catch of brown trout next to a "Tally-Ho" stagecoach, circa 1910.

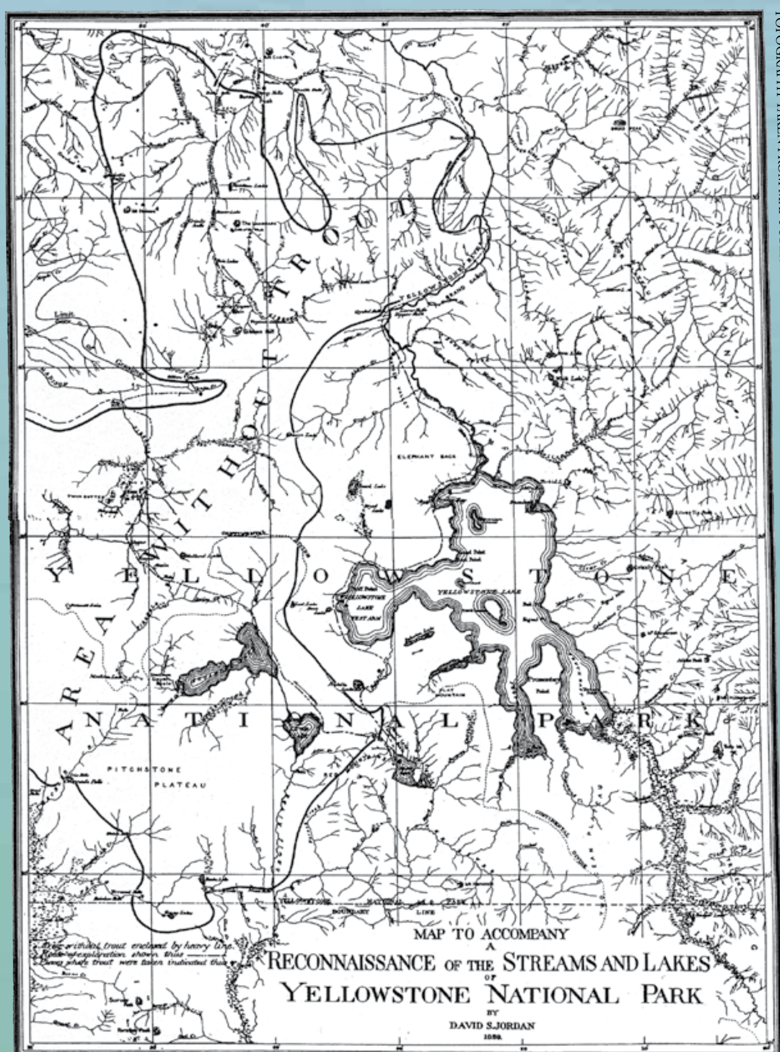

YELL–43549

Visitors disembark from their boats on the docks of Yellowstone Lake and a young fisherman displays his considerable catch.

Largely because of these activities and the popularity of Yellowstone's fisheries, recreational angling became an accepted use of national parks throughout the country. In Yellowstone, fisheries management, as the term is understood today, began with the U.S. Army, and was taken over by the National Park Service in 1916. Fish stocking, data gathering, and other monitoring activities initiated by the U.S. Fish Commission in 1889 were continued by the U.S. Fish and Wildlife Service until 1996, when they became the responsibility of the National Park Service.

Approximately 48% of Yellowstone's waters were once fishless (Jordan 1891), and the stocking of nonnative fishes by park managers has had profound ecological consequences. The more serious of these include displacement of intolerant natives such as westslope cutthroat trout (*O. clarkii lewisi*) and Arctic grayling (*Thymallus arcticus*), hybridization of Yellowstone (*O. c. bouvieri*) and westslope cutthroat trout with each other and with nonnative rainbow trout, and, most recently, predation of Yellowstone cutthroat trout by nonnative lake trout. Over the years, management policies of the National Park Service have drastically changed to reflect new ecological insights (Leopold et al. 1963). Subsistence use and harvest orientation once guided fisheries management. Now, maintenance of natural biotic associations or, where possible, restoration to pre-Euro-American conditions have emerged as primary goals. Eighteen fish species or subspecies are known to exist in Yellowstone National Park; 13 are considered native (they were known to exist in park waters prior to Euro-American settlement), and 5 are introduced (nonnative or exotic; see Appendix i) (Varley and Schullery 1998).

A perceived conflict exists in the National Park Service mandate to protect and preserve pristine natural systems and provide for public use and enjoyment (NPS 2006). Fisheries management efforts in Yellowstone are currently focused on preservation of native species while allowing for use of these fisheries by anglers through a catch-and-release requirement. Because the primary mission of Yellowstone's Fisheries and Aquatic Sciences Program (Fisheries Program) is the preservation of natural ecosystems and ecosystem processes, it does not emphasize maintenance of nonnative fish stocks. In fact, harvest regulations have been liberalized to encourage anglers to keep nonnative trout caught in waters where they are harming native cutthroat trout or Arctic grayling. Fisheries Program activities are focused almost exclusively on the preservation of Yellowstone Lake cutthroat trout, the restoration of fluvial (stream-resident) populations of native trout, and the research and monitoring needed to support these critical activities.



TOPOGRAPHY TAKEN FROM MAP PUBLISHED IN 1886, BY THE U.S. GEOLOGICAL SURVEY

Fisheries authority David Starr Jordan produced this map of Yellowstone waters in 1889, showing the large portion of the western side of the park as an AREA WITHOUT TROUT, *in anticipation of the extensive stocking program that followed. (From Barton W. Evermann, Report on the Establishment of Fish Cultural Stations in the Rocky Mountain Region and Gulf States, U.S. Government Printing Office, 1892).*

...harvest regulations have been liberalized to encourage anglers to keep nonnative trout caught in waters where they are harming native cutthroat trout or Arctic grayling.

2008 Summary

Lake trout suppression efforts started late in 2008 due to cold spring weather, yet staff removed 76,136 lake trout, the highest annual number on record. More than 11,400 of these were adults caught during the late August to early October spawning season, including the largest lake trout ever netted from Yellowstone Lake. We estimated that this female fish, which weighed 10.89 kg (24 lbs, 6 oz) and was 982 mm in total length, was 12 years old based on examination of its otolith (ear bone). Both the number of lake trout removed and the catch-per-unit-effort has steadily increased each year since the suppression project began, which is a serious cause for concern.

Indices of abundance suggest that the Yellowstone Lake cutthroat trout spawning population has yet to demonstrate a significant positive response to our lake trout suppression efforts. Our weir and fish trap at Clear Creek failed during spring flood flows in 2008, precluding an accurate count of upstream-migrating cutthroat trout. We handled only 241 cutthroat trout from mid-May to mid-June, prior to the weir failure. Historically, Clear Creek supported more than 30,000 spawning cutthroat trout, but those numbers have not been seen since the mid-1990s.

Cutthroat trout abundance has also been monitored annually by a fall netting assessment at sites across Yellowstone Lake. This year, an average of 9.2 cutthroat trout per gillnet were captured, up slightly from the 9.1 captured last season, and our highest average since 1998 when 9.9 fish/net were caught. Approximately 38% of our catch consisted of fish greater than 330 mm in total length, the minimum length when cutthroat trout in the lake system are thought to mature.

The East Fork Specimen Creek westslope cutthroat trout restoration project focused on completion of a log fish barrier followed by rotenone treatment of waters upstream. The barrier was built three miles from the trailhead at Highway 191, in an area that burned in the 2007 Owl Fire. Two rotenone treatments completed in August extended from the waterfall at High Lake downstream to the fish barrier. A third and final chemical treatment of this watershed is planned for 2009.

Westslope cutthroat trout from both of the genetically unaltered populations known within the park were used in our continued effort to restock High Lake following its 2006 rotenone treatment. Embryos from Last Chance Creek and the Sun Ranch upper Missouri River broodstock were introduced using remote site incubators placed in High Lake inlet streams. Juveniles and adults were collected from the Oxbow/Geode Creek complex and moved to High Lake via helicopter. Monitoring indicated initial success of all 2008 High Lake stocking efforts. The introduction of westslope cutthroat trout to High Lake is expected to continue in 2009.

NPS/T. KOEL

A westslope cutthroat trout from High Lake.

The ecological health of the park's aquatic systems continues to be monitored. The quality of the surface waters is monitored monthly at 12 fixed sites near the confluences of major streams and rivers (Figure 1). The physical and chemical characteristics of Yellowstone Lake are monitored seasonally to assist the targeting of nonnative lake trout. Emphasis continues to be placed on the assessment of potential impacts of rotenone on non-target species during the East Fork Specimen Creek fish restoration.

The Fly Fishing Volunteer Program continues to be an integral mechanism for communicating information and raising public awareness of issues facing Yellowstone's native fishes. This year 89 volunteers participated in the program, contributing 1,885 hours to projects throughout the park. They assisted with the Specimen Creek westslope cutthroat trout restoration and the documentation of cutthroat trout genetics, especially in Slough and Soda Butte creeks. By marking trout, the volunteers are assessing the effectiveness of existing waterfalls and cascades for restricting upstream movement of trout in several streams. This information has been instrumental in guiding native trout restoration in Yellowstone.

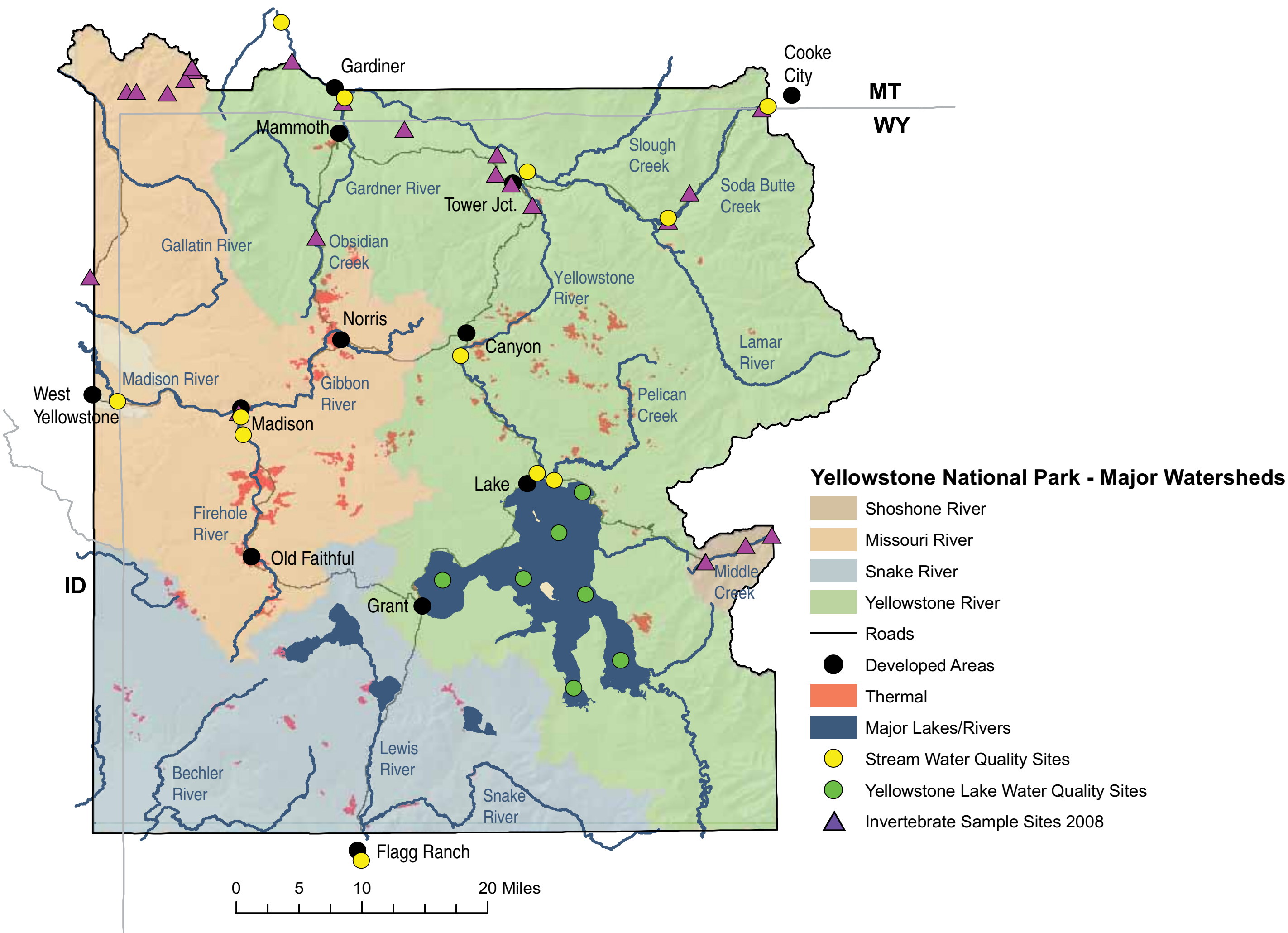


Figure 1. Major watersheds and surface waters of Yellowstone National Park, with sites established for long-term water quality monitoring on streams (12 sites–yellow circles) and Yellowstone Lake (7 sites–green circles). Areas sampled for aquatic invertebrates in 2008(24 sites–purple triangles) are also shown.

The Fisheries Program

Primary Emphasis Areas

The aquatic resources of Yellowstone National Park and the ecosystems they support are threatened by the presence of species that are nonnative (from elsewhere in North America) and exotic (from another continent). For the foreseeable future, the Fisheries Program will focus the greatest effort on two priorities: (1) preservation of cutthroat trout in Yellowstone Lake, which is the largest remaining concentration of genetically unaltered inland cutthroat trout in the world; and (2) restoration of fluvial populations of native trout, many of which have been lost because of nonnative species introductions.

The lake trout suppression effort to preserve Yellowstone Lake cutthroat trout is one of the largest nonnative fish removal programs in the United States. Activities related to fluvial populations of native trout include westslope cutthroat trout restoration in the East Fork Specimen Creek watershed and planning/compliance efforts leading toward Yellowstone cutthroat trout restoration on streams across the northern range.


NPS/T. KOEL

Fisheries technician Derek Rupert stocks westslope cutthroat trout eggs on an inlet stream of High Lake.


NPS/W. VOIGT

Young volunteers load fish into a net placed in Specimen Creek.


NPS/T. KOEL

Student Conservation Association intern Sam LaMott and aquatic ecologist Jeff Arnold sample water quality at a pond near Slough Creek and the Lamar River.


CASEY KOLESKI

Student Conservation Association Intern Molly Payne and employee Chelsey Young work the "slime line."


ALEXIS WOLF

Fisheries technicians Scott Brown and Brian Ertel electrofishing in Amphitheater Creek.

Preservation of Yellowstone Lake Cutthroat Trout

Yellowstone Cutthroat Trout Long-term Monitoring

Historically, the Yellowstone Lake cutthroat trout population has been the largest remaining, genetically unaltered population of Yellowstone cutthroat trout in the world (Behnke 2002). However, impacts of the introduction of lake trout, *Myxobolus cerebralis* (which causes whirling disease), and extended drought have negatively affected this population. Long-term monitoring of the Yellowstone Lake ecosystem shows a substantial decline in the number of cutthroat trout since 1988. The number of upstream migrating cutthroat trout in Clear Creek (Figure 2) has declined from 54,928 in 1988 to just 538 in 2007 (Figure 3a). Mean total length of upstream migrants has increased from 393 mm to 523 mm during that same period. The apparent lack of recruitment and aging spawning population continue to put this population at serious risk of extirpation.

The Clear Creek fish trap and weir were operated beginning on May 14, 2008, and ending on June 16, 2008, when the structure was heavily damaged by high spring flows. Because of this damage, we were unable to conduct a complete count of the spawning run; however, we sampled 241 upstream migrating Yellowstone cutthroat trout during trap operations (Figure 3a). The cutthroat trout averaged 532 mm in total length, a slight increase from 2007. For the second consecutive year we sampled a small number of cutthroat trout below 400 mm in

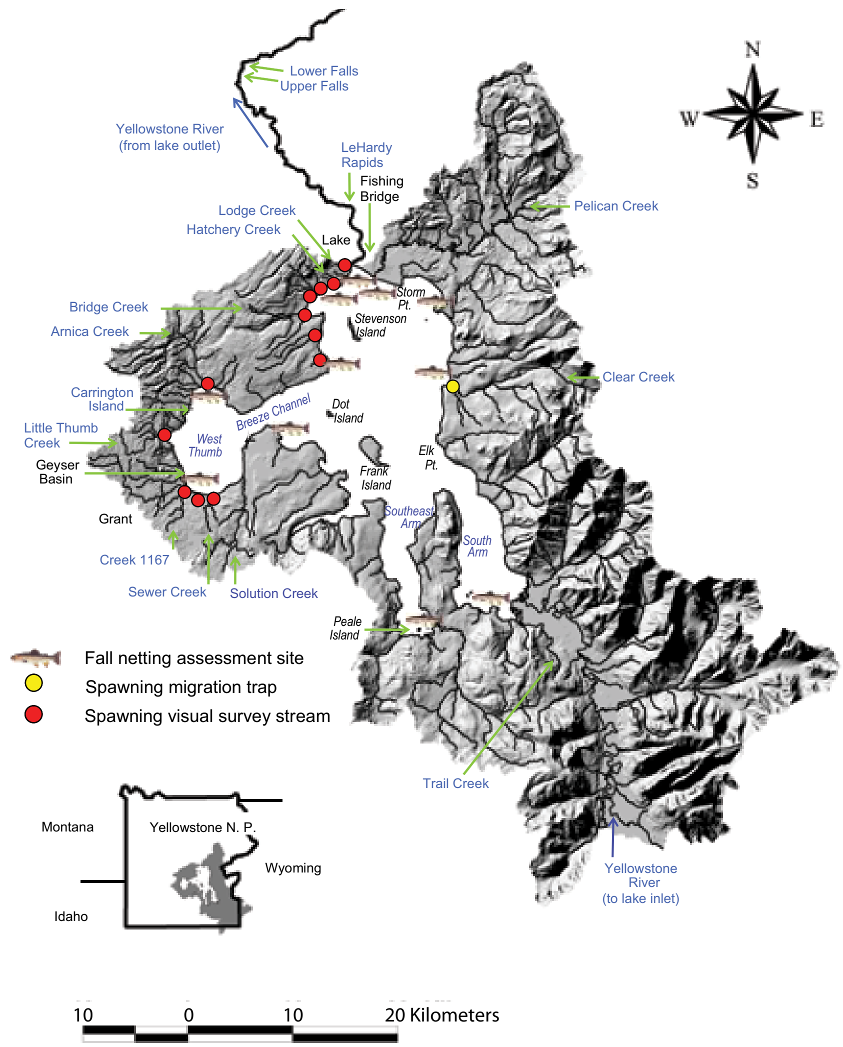


Figure 2. Yellowstone Lake and several major tributary drainages within Yellowstone National Park.

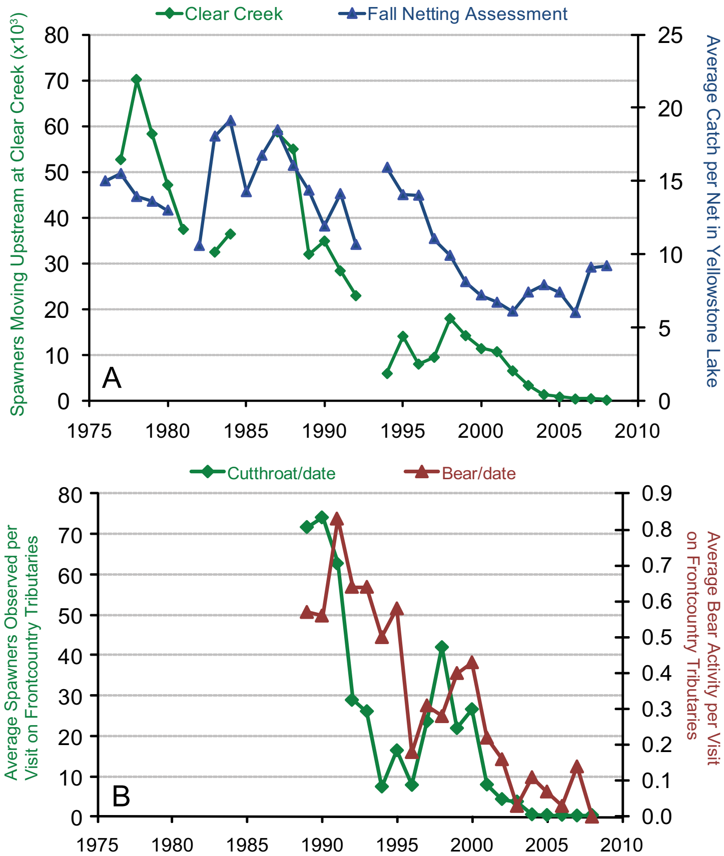


Figure 3. (A) Total number of upstream-migrating cutthroat trout counted at the Clear Creek spawning migration trap and mean number of cutthroat trout collected per net during the fall netting assessment on Yellowstone Lake (1976–2008) and (B) mean number of cutthroat trout and mean activity by black bears and grizzly bears observed during weekly spawning visual surveys of 9–11 tributaries along the west side of Yellowstone Lake between Lake and Grant, 1989–2008. On Yellowstone Lake, population estimates were made using mark-recapture during 1979 (Jones et al. 1980) and sonar technology during 1992 and 1997 (McClain and Thorne 1993; Ruzycki et al. 2003). Cutthroat trout abundance within the lake was approximately 3.5 million in 1979 (>350 mm length), but fell to 1.2 and 1.7 million (>100 mm length) in 1992 and 1997, respectively. No lake-wide estimate is available for the current population.

total length. This is significant as these fish are most likely first-time spawners; these fish had been largely absent from our samples during 2002–07. Damage to the weir and supporting structures in 2008 was significant enough to warrant a complete rebuild. Because of this we will not be able to operate the weir and trap during the 2009 spawning season.

Since 1969, cutthroat trout in Yellowstone Lake have been monitored annually with a gillnet assessment. Five gillnets are set for one night at each of 11 sites around the lake (Koel et al. 2005). Nets are approximately 38 meters long and made up of five different mesh size panels. Each net set begins at a depth of 1–2 meters with the smallest mesh and runs perpendicular to shore. Nets are set approximately 100 meters apart to limit shadowing. In 2008, an average of 9.2 cutthroat trout per gillnet were captured, up slightly from the 9.1 captured in 2007, and our highest average since 1998 when 9.9 fish/net were caught (Figure 3a). Approximately 38% of our catch consisted of fish greater than 330 mm in total length, the minimum length when cutthroat trout in the lake system are thought to mature. This is similar to the catch in 2007 and several years leading up to when lake trout were believed to be introduced (1986, 40% and 1987, 41%; Figure 4). However, what is not evident in recent years are fish in the 200–250 mm range surviving to adulthood (>330 mm). This may be a result of the introduction of lake trout, a top aquatic predator, into the lake ecosystem. We hope that continued efforts to suppress the lake trout population (see below) will allow for

Fisheries technician Brian Ertel and Student Conservation Association interns Kate Olson and Brendan Crowley work to remove a damaged weir from Clear Creek.

At the annual assessment of the spawning run at Clear Creek, Yellowstone cutthroat trout are sampled.

more cutthroat trout to survive to spawning age.

The prevalence of cutthroat trout as well as bear activity is estimated annually by walking the stream banks of 9–11 tributaries along the west side of the lake between Lake and Grant (Reinhart and Mattson 1990; Reinhart et al. 1995; Figure 3b). These surveys indicate a significant decline of spawning-aged cutthroat trout in Yellowstone Lake, and the variation in spawner abundance (the annual means in all surveyed tributaries) follows a trend very similar to that observed at Clear Creek (Figure 3a). Spawning cutthroat trout declined for several years after the 1988 fires and comparatively low numbers spawned in 1994–95. A slight rebound occurred after the high water years of 1996–97, but since then numbers of spawning cutthroat trout showing up in tributaries have fallen annually to unprecedented levels. Of great concern is the potential impact of this decline on consumer species. Bear activity at the 9–11 frontcountry streams has mirrored the spawning cutthroat trout decline, revealing the cascading effects of the cutthroat trout loss (Figure 3b; Koel et al. 2005; Gunther et al. 2008).

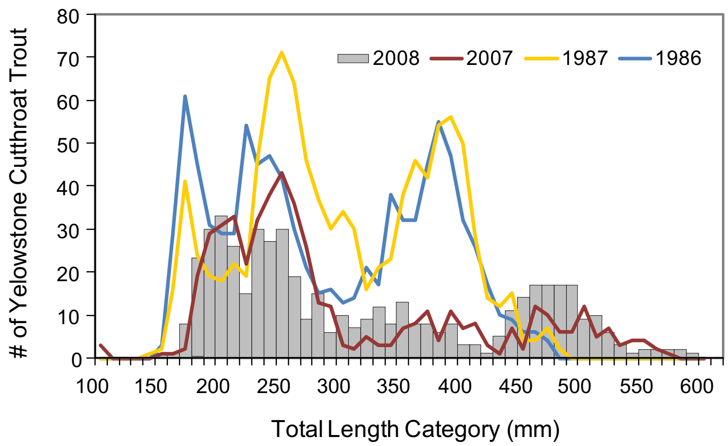


Figure 4. Length-frequency distributions of cutthroat trout collected during the fall netting assessment on Yellowstone Lake following high (2007–08) and no (1986–87) predation pressure by nonnative lake trout. The 1986-87 cutthroat trout population was free from most threats and had a healthy size/age structure. Now the population size structure indicates significant predation pressure from lake trout, with an apparent failure of recruitment to maturity for multiple year classes.

Looking upstream to the damaged weir on Clear Creek that was removed and replaced by fisheries technicians.

Yellowstone sulphur wild buckwheat, an endemic plant species that grows in the Clear Creek area.

NPS/T. KOEL

Mending and preparing gill nets for deployment.

Lake Trout Suppression Program

Lake trout, intentionally stocked in Lewis and Shoshone lakes in 1890 by the U.S. Fish Commission, were illegally introduced into Yellowstone Lake and are a serious threat to the native Yellowstone cutthroat trout population. In 2008, suppression efforts started on June 3, due to cold spring weather, and ended on October 21. Setting a total of 17,485.2 net units (one net unit is 100 meters of gill net fishing for one overnight period), we removed 76,136 lake trout, the highest annual number on record (Figure 5a). More than 11,400 of these were caught while targeting adults during the late August to early October spawning season (Figure 5b), including the heaviest lake trout ever netted from Yellowstone Lake. We estimated that this female fish, which weighed 10.89 kg (24 lbs 6 oz) and was 982 mm in total length, was 12 years old, based on examination of its otolith (ear bone). Both the number of lake trout and the catch-per-unit-effort has steadily increased each year of the suppression project, which is a serious cause for concern.

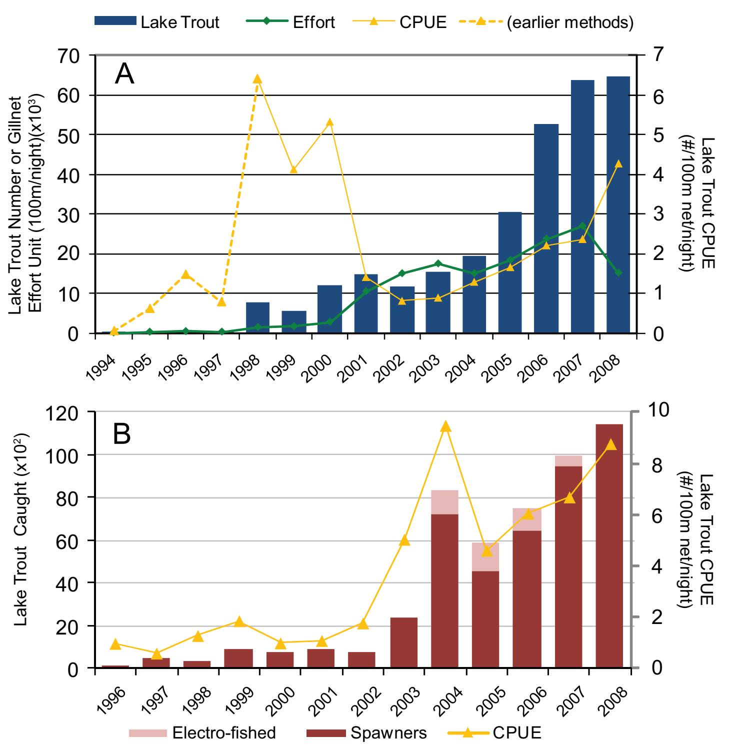


Figure 5. (A) Number of lake trout removed, gill net units of effort (1 unit = 100 m of net/night), and lake trout catch per unit of effort obtained with control nets, 1994–2008. (B) Number of mature lake trout removed by gillnetting and boat-mounted electrofishing near Yellowstone Lake spawning locations (Breeze Channel, Carrington Island, Geyser Basin, and Solution Creek) late August–early October, 1996–2008.

Lake Trout Control Netting

The majority of our suppression effort has targeted juvenile lake trout in deep water of Yellowstone Lake (control netting). This gillnetting occurs along the lake bottom in water typically 30–60 meters deep, with nets extending up from the bottom approximately 2.5 meters. Several mesh sizes (25, 32, and 38 mm bar measure) are used to target the smaller, juvenile lake trout that reside at these depths. The control netting begins as soon as ice is breaking up on the lake. Workers check and reset gill nets on a rotational basis with the goal of processing each

NPS/T. KOEL

Student Conservation Association intern Shane Scranton removes lake trout from a gill net on Yellowstone Lake.

net at least once a week. During the peak of the 2008 field season more than 16,000 lineal meters (10 miles) of gill net were in the lake each day. The number of lake trout removed by control netting alone was 64,675 in 2008, second only to the number caught in 2007 (63,776; Figure 5a). The nets were set at depths of 15.9 to 64.6 meters (mean = 40.7 m), which included many nets set shallower than in recent years.

Lake Trout Spawner Removal

In 2008, we began targeting mature lake trout on August 18 and continued until October 10. Gill nets in mesh sizes 32, 38, 44, 51, 57, 64, 76, and 89 mm (1.25–3.5 inch) bar measure were set along the bottom at depths of 2.4 to 42.4 meters (mean = 20.5 m). A total of 11,461 lake trout were removed while targeting adults, of which 11,187 (63.8%) were mature. This is the most adult lake trout ever removed in a given spawning season (Figure 5b). Of the 7,584 adult lake trout measured and analyzed for spawning condition, 51% were pre-spawn (green), 46% were ready to spawn or in spawning (ripe) condition, and 3% had already spawned (spent).

NPS/T. KOEL

Removal efforts on Yellowstone Lake require teamwork.

NPS/T. KOEL

Lake trout can be identified by their combination of light spots and deeply forked tail.

The average total length of females was 571.9mm; of males, 514.7mm. Of the 313 spawner net sets, 162 (51.8%) fished for only one night; the average soak time was 2.1 nights. As the water cooled in the fall, the gill nets were set in shallower water. The highest CPUEs were in nets set 8–28 meters deep for only one night during September 16–23. Carrington Island, the longest known and hardest hit lake trout spawning area, accounted for 6 of the 11 net sets with the highest CPUE. The Flat Mountain Arm site, more recently found, accounted for 3 of the top 11 spawner sets, and was where the largest lake trout on record was captured in 2008.

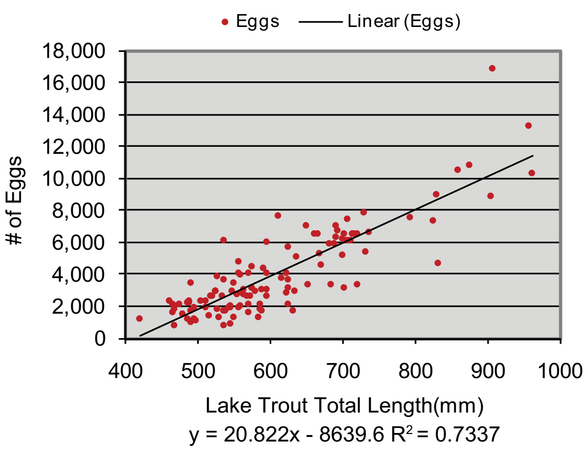
NPS/T. KOEL

Biologists can approximate fish age by measuring length.

Mount Sheridan rises over the ice covering the surface of Yellowstone Lake. The surface of the lake will not be completely free of ice until as late as June. That leaves a short period of time in which to conduct all of the lake trout removal and cutthroat trout monitoring efforts.

Lake Trout Fecundity

To assess fecundity, we estimated the number of viable ripening eggs in the ovaries of 119 green female lake trout that were 420–962 mm in total length and weighed 0.95–11.0 kg. The number of viable eggs per fish ranged from 798 to 16,834 and was highly correlated with total length and weight (r^2=0.73 each; Figure 6). Based on these data, our removal of 1,729 mature female lake trout in 2008 potentially prevented >5 million eggs from being spawned in the system.



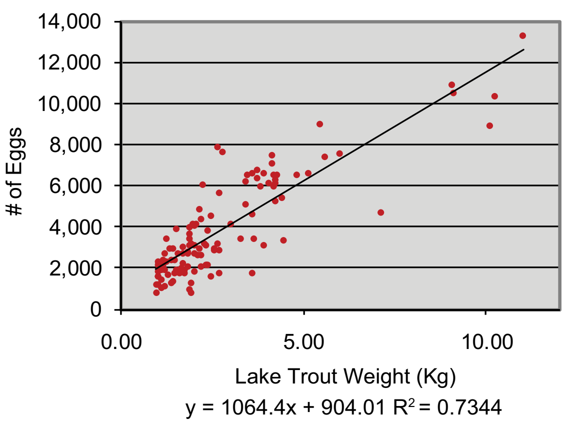


Figure 6. Estimated fecundity (number of eggs) held by female lake trout from Yellowstone Lake. Each female removed by the suppression program prevents thousands of eggs from being spawned.

Incidental Catch of Cutthroat Trout

The total number of Yellowstone cutthroat trout caught in lake trout gill nets during 2008 was 3,376, only 60% of the 5,661 caught in 2007. We were able to accomplish this because of our focused effort in 2008 (about 60% of 2007) and by removing mesh sizes that seasonally catch high numbers of cutthroat trout. Based on past experience, the 25-mm mesh nets tend to have increased cutthroat trout bycatch, especially in the fall. Another netting strategy to avoid cutthroat by-catch is the practice of halting repetitive sets at a location when lake trout catches there decrease. At many of the areas in the lake, initial net sets have the highest CPUEs for lake trout and the lowest for cutthroat.

Science Panel Review and Recommendations

August 25–29, 2008, a blue-ribbon panel of experts convened to 1) critically evaluate the effectiveness of the lake trout suppression program in Yellowstone Lake, including its effects on lake trout and Yellowstone cutthroat trout populations, and associated ecosystem responses; 2) review emerging technological opportunities for suppressing lake trout; and 3) provide alternatives for the future direction of the program in the context of the primary mission of the National Park Service (to ensure the long-term persistence of native Yellowstone cutthroat trout and the Yellowstone lake ecosystem).

During the workshop, park employees and outside researchers presented pertinent data to the panel. Panelists observed lake trout suppression operations during a field trip on Yellowstone Lake aboard the NPS *Freedom,* assessed the program during closed-door discussions, and then presented their findings and recommendations to park staff. The panel

Seasonal lake trout suppression efforts began on June 3, 2008, and ended on October 21, 2008. Despite the abbreviated season, 76,136 lake trout were removed by staff and volunteers—the highest annual number on record.

found that the current program has been effective in reducing lake trout predation on cutthroat trout; however, the decline of the cutthroat trout population in Yellowstone Lake continues and the program has not driven the lake trout population into decline. Although many emerging technologies showed promise in aiding lake trout suppression, none are ready for immediate implementation and they should be components of a research program to support future decisions. The panel found that an intensified removal program could drive the lake trout population into decline; however, the amount of removal pressure needed to achieve that decline could not be determined based on the current analyses. The panel recommended that we:

- intensify lake trout removal efforts for a minimum of six years;
- maintain current resources and use professional fishers to augment efforts, initiate movement and distribution studies, set benchmarks for lake trout control;
- experiment with alternatives while monitoring effectiveness;
- maintain and enhance cutthroat trout monitoring programs by continuing to count cutthroat trout on Clear Creek and on other spawning streams;
- continue cutthroat trout assessment throughout the lake using a fall gillnet program;
- initiate a statistically robust lake trout monitoring program;
- complete a review and statistical analysis of existing data.

The panel also noted that increased agency administrative commitment to lake trout suppression will be needed to meet established benchmarks and increase the effectiveness of lake trout removal and conservation of the Yellowstone Lake ecosystem through the coming decades.

NPS/J. PEACO

After an intensive, three-day review, Bob Gresswell of the US Geological Survey delivers the findings and recommendations of the Science Panel to National Park Service personnel.

Stream Resident Cutthroat Trout and Grayling Conservation

Westslope Cutthroat Trout Source Populations

Over the past four years, two populations of genetically unaltered (without detectable hybridization) westslope cutthroat trout have been discovered in Yellowstone National Park. A small tributary of Grayling Creek, now known as "Last Chance Creek," contains the only remaining indigenous population of westslope cutthroat trout known in the park (Figure 7). The Oxbow/Geode Creek stream complex in the Yellowstone River drainage is home to a genetically unaltered population of westslope cutthroat trout that were apparently stocked there in the 1920s (Figure 8). Both populations have been independently verified as genetically unaltered by multiple laboratories (Appendix iv) and both have been found to be free of pathogens. The confirmation of genetic integrity and clean bill of health make these two populations extremely valuable to current and future westslope cutthroat trout restoration both within the park and around the region. Both populations were utilized this year in the High Lake restocking effort (see below) and gametes from the Last Chance Creek population were incorporated into the upper Missouri River brood stock at the Sun Ranch Hatchery near Ennis, Montana.


NPS/D. RUPERT

Geode Creek electrofishing crew.

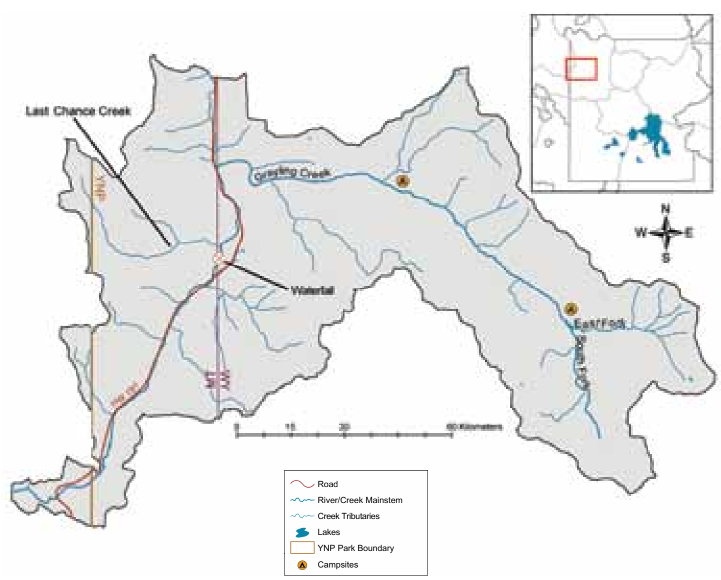


Figure 7. The Graying Creek watershed within Yellowstone National Park and the Gallatin National Forest, Montana and Wyoming. An existing bedrock waterfall lies immediately downstream of Last Chance Creek, location of the park's only known indigenous westslope cutthroat trout population. Camping areas indicated were used during fish and habitat surveys of this remote backcountry watershed.

High Lake Westslope Cutthroat Trout Introduction

Following the removal of nonnative fish in 2006 and the initiation of restocking efforts in 2007, the reintroduction of westslope cutthroat trout into High Lake continued to be a priority in 2008. In addition to the park's two known genetically unaltered populations, eggs from the upper Missouri River brood stock were used in the restocking. On July 5, 2,844 eyed-eggs from


NPS/D. RUPERT

A westslope cutthroat trout from High Lake.

NPS/T. KOEL

Westslope cutthroat trout from Geode Creek that was stocked into High Lake in July 2008.

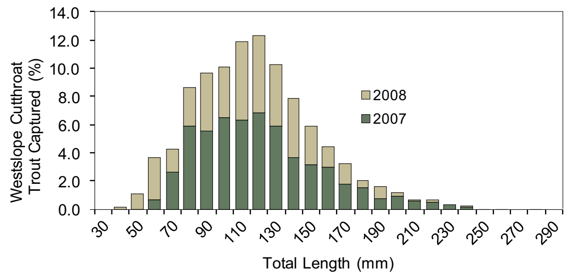


Figure 9. Length-frequency distribution of westslope cutthroat trout collected from Geode Creek and moved to High Lake in 2007 and 2008.

the Sun Ranch were flown to High Lake via helicopter and placed in remote site incubators (RSIs). Three weeks later, 286 fertilized eggs collected from 8 female and 13 male fish in Last Chance Creek were taken to High Lake on horseback and placed in RSIs. On July 7 and 9, a total of 890 westslope cutthroat trout of various age-classes (Figure 9) were flown from the Oxbow/Geode Creek complex to High Lake via helicopter.

Subsequent monitoring indicated initial success of the 2008 stocking efforts; however, some eggs from the Sun Ranch brood were lost because RSIs failed when flows of inlet streams declined. Eggs in RSIs that remained adequately submerged appeared to have a high hatching success rate, as indicated by the low number of dead eggs found in the incubators and an abundance of fry visible in the inlet streams. Fry were also observed in various locations around the lake margin. Adult fish were seen within the littoral zone feeding on aquatic invertebrates and several were captured by hook and line. The captured adults appeared robust and healthy when released. Campers in the area reported a family of otters inhabiting the lake, indicating that fish-dependent wildlife are returning to the area.

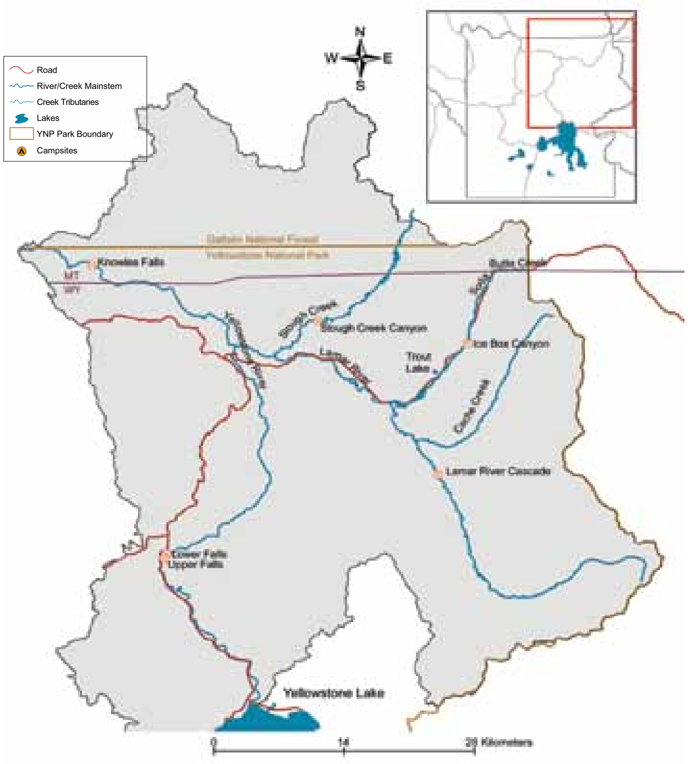
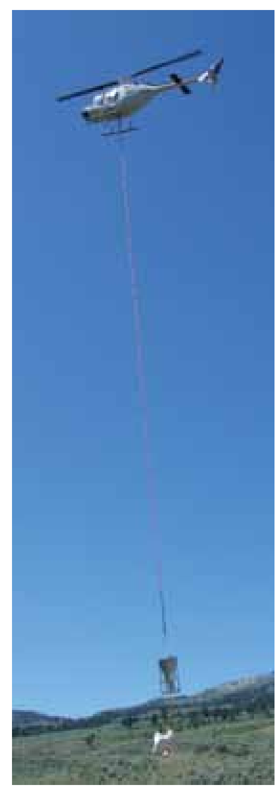


Figure 8. Yellowstone River drainage from Yellowstone Lake to the park boundary near Gardiner, Montana, with locations of known or potential barriers to fish movement.

East Fork Specimen Creek Fish Barrier

Following project delays and complications caused by the 2007 Owl Fire, fish barrier construction on East Fork Specimen Creek was undertaken in earnest in 2008. This backcountry effort began with the movement of materials to the site (Figure 10), including several helicopter sling loads and 93 stock loads of tools and supplies. Following pack-in, hazard trees were removed from the site to mitigate safety concerns resulting from the fire.



NPS/D. RUPERT

A helicopter delivers westslope cutthroat trout to High Lake from Geode Creek.

Hazard tree removal and barrier construction were overseen by Intermountain Restoration Inc. (Richard Teer, Wilsall, MT), and much of the intense manual labor required for the project was provided by the Montana Conservation Corps. In all, dozens of people, including park staff from almost every division, aided in seeing the project to a successful completion. The final result is a double-walled log structure nearly 6 feet high and more than 40 feet wide. Water is directed over the middle of the structure through a set of weir notches and falls onto a concrete splash pad. Visual inspection indicates that the structure should be a complete barrier to upstream fish movement, although only time, and the attempted passage by nonnative fish, will tell.

Clockwise from top left: A Montana Conservation Corps (MCC) crew uses rocks to secure the liner of the barrier; Mike Ruhl and Derek Rupert gauge the depth of the water diversion channel; Mike Ruhl and Derek Rupert assess the performance of the barrier after heavy rain (water diversion structure in the back); MCC crew mixes concrete.

NPS

Piscicide treatment of East Fork Specimen Creek.

Portable barriers restrict fish movement during the Specimen Creek treatment.

East Fork Specimen Creek Piscicide Treatment

The completion of the East Fork Specimen Creek fish barrier in August paved the way for nonnative fish removal to begin in the upstream project area (Figure 10). Treatments were initiated on August 18 and 21 using the EPA-approved piscicide CFT Legumine (rotenone), the same chemical used in the 2006 treatments of High Lake, and were based on travel time estimates, flow calculations, and bioassays conducted immediately pre-treatment. The same procedure was followed for both treatments: (1) piscicide application from metered stations (drip buckets) along the creek and its large tributaries, (2) application of dilute piscicide from backpack sprayers to small tributaries and backwaters, and (3) application of a rotenone-sand matrix to springs and seeps along the creek. Each treatment required two days to complete, beginning at the waterfall just below High Lake and ending immediately downstream of the fish barrier. The rotenone was neutralized at the end of the treatment area using potassium permanganate dispensed from a volumetric feeder.

The first treatment appeared successful except for a small stream segment near High Lake. The second treatment, which was adapted to address the missed area, appeared to be a complete success. The efficacy of

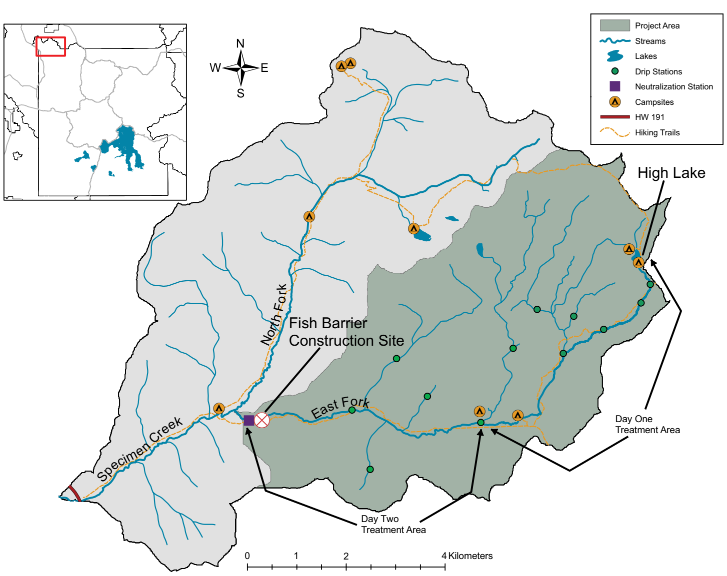


Figure 10. Project area for westslope cutthroat trout recovery in East Fork Specimen Creek, with locations of a constructed fish barrier, rotenone drip stations, and a potassium permanganate neutralization station in 2008.

both the treatments and the neutralization was monitored with sentinel fish placed in cages in the stream.

Given the inherent difficulty of achieving a complete removal of nonnative fish from such a large area, the same treatments will be repeated in 2009. These treatments, coupled with extensive monitoring, should demonstrate the efficacy of both the 2008 treatments and the fish barrier. If the treatments are found to be successful and the fish barrier proves effective, we expect to begin restocking genetically unaltered westslope cutthroat trout into the stream in 2010.


NPS/J. SKORUPSKI

An Arctic grayling at Grebe Lake.

Potential of Returning Arctic Grayling to Grayling Creek

Since 2007 we have teamed with biologists at the Montana Department of Fish, Wildlife and Parks to assess Grayling Creek for a potential fluvial Arctic grayling and westslope cutthroat trout restoration project (Koel et al 2007; Figure 7). The 2007 survey indicated that although the creek is occupied by brown trout and hybridized cutthroat trout (Appendix iv), it may be suitable for fluvial Arctic grayling upstream of the upper falls. The interagency cooperation continued in 2008 with another multi-day trip into the remote drainage. This year we focused on collecting fish composition, distribution and genetic data from the stream's headwater reaches. Genetic samples were collected from the main stem of Grayling Creek just below the confluence of the forks, from the upstream meadows of each fork, and from a tributary of south fork Grayling Creek. Visual inspection of fish from both the south fork and its fish-inhabited tributary indicate far less hybridization than in the main stem or east fork reaches. Brown trout were captured in both the main stem and the east fork, indicating the stream's accessibility to nonnative species. The genetic analysis scheduled for early 2009 will indicate the degree of genetic purity in the sampled reaches. The 2008 survey revealed the need to continue searching Grayling Creek's tributaries for additional, isolated, genetically unaltered populations of westslope cutthroat trout. The park's fisheries staff, along with their agency partners, will continue detailed surveys of the drainage in the coming years. This information will be useful for identifying potential genetically unaltered westslope cutthroat trout and delineating the extent of fish distribution for future restoration efforts.


NPS/W. VOIGT

A brown trout caught above the Grayling Creek waterfall.

Recent and On-going Invasions on the Northern Range

A common misconception about native fish in Yellowstone is that park waters that now contain only native fish are safe from invasion by nonnative fish. Unfortunately, the "species landscape" is not static and park waters are still vulnerable. Several extensive watersheds that were historically inhabited by Yellowstone cutthroat trout waters have been compromised in recent years.


NPS/W. VOIGT

A cutthroat trout from Slough Creek.

NPS/T. KOEL

Rainbow trout and rainbow-cutthrout hybrids have been found increasingly further upstream in Slough Creek. This boulder field (B) and cascade (C) have proven to be insufficient barriers to the upstream movement of rainbow trout from the Slough Creek campground (A), where they have previoulsy been identified, to the first meadow (D).

The upper meadows of Slough Creek, one of the park's most cherished cutthroat trout fisheries, was long believed to be a secure stronghold for genetically unaltered fish. However reports of rainbow trout upstream of the Slough Creek canyon began to arise from reliable sources early in this decade. Through genetic examination, biologists confirmed the presence of rainbow trout genetic material in the first meadow of Slough Creek in 2002 (analyzed in 2006), and in the canyon above the first meadow in 2007 (see Appendix iii). To date rainbow trout influence has not been demonstrated in Slough Creek's upper third meadow in the park, although angler reports indicate the invasion may have spread to that area. Additional genetic analyses are forthcoming. The source of the rainbow trout remains uncertain, but the Slough Creek canyon appears to lack a definite barrier to upstream fish movement and the low water years of the mid-2000s may have facilitated upstream fish movement. It is also possible that rainbow trout were once stocked, and have persisted, in waters connected to upper Slough Creek and are now entering the system through downstream drift. Determining the source of the Slough Creek rainbow trout invasion will be the first step in mitigating this threat. As such, this has become a top fisheries priority for the system.

Soda Butte Creek is experiencing a rainbow trout invasion similar to that in Slough Creek. Initial angler reports, later confirmed by

NPS/W. VOIGT

A cutthroat-rainbow trout hybrid from Slough Creek.

genetic analyses, have verified the movement of rainbow trout into the system. This problem is confounded by a nonnative brook trout invasion from upstream sources (see below). Like Slough Creek, Soda Butte Creek is a beloved fishery and has long stood as an important Yellowstone cutthroat trout stronghold. The most likely source of rainbow trout invaders is lower Soda Butte Creek and the Lamar River entering through Ice Box Canyon. A site visit by US Forest Service engineer Dale White during 2008 revealed that fish passage through the canyon may be possible. However, it does appear that minimal alterations to the Ice Box Canyon cascades could make the feature a complete barrier to upstream fish movement and thereby halt the invasion. Careful consideration and NEPA compliance would be conducted before any significant action is taken on either stream.

In addition to the rainbow trout invasions of Slough and Soda Butte creeks, it now appears that the Yellowstone River upstream of Knowles Falls is being invaded by brown trout. Knowles Falls, a 5-meter tall cascade waterfall, is located 13 miles downstream from the confluence of the Yellowstone and Lamar rivers. This feature has long been thought to be at the uppermost extent of brown trout distribution in the Yellowstone River (Varley and Schullery 1998). However, in 2008 a former fisheries biologist caught a brown trout from the river near Tower, over 17 miles upstream of Knowles Falls. If brown trout have become established above Knowles Falls, at least 36 miles of the Yellowstone River, over 23 miles of the Lamar River, Slough Creek, Soda Butte Creek, and many other named and unnamed tributaries are at risk. Methods to evaluate and mitigate for this new nonnative threat are being considered.

Soda Butte Creek Brook Trout Removal

The nonnative brook trout that have been residing in the uppermost reaches of Soda Butte Creek (upstream of the McClaren Mine site) for several decades have been moving downstream and into the park. This is serious because cutthroat trout and brook trout often cannot coexist in a stream. If not controlled, the brook trout would drastically reduce the number of cutthroat trout and could eventually extirpate them from the system. In an attempt to curtail the brook trout impacts, for the past five years biologists from the Montana Department of Fish, Wildlife and Parks, the U.S. Forest Service, and Yellowstone National Park have been intensely electrofishing in the Soda Butte Creek drainage from the headwaters to Warm Spring. In September 2008, this electrofishing was extended downstream to Ice Box Canyon and Amphitheater Creek (Figure 11).


A. WOLF

Brian Ertel carries an electrofishing pack through Amphitheater Creek.

Catches of brook trout have declined each year, indicating that the removal efforts have been successful (Table 1). The 2008 removals produced just 48 brook trout, compared to 1,104 in 2005. Similar to 2007, a large portion (48%) of the brook trout were found between the park boundary and Warm Spring. Only three were removed between Warm Spring and the road bridge (Figure 11). Sampling from the road bridge to Ice Box Canyon found no brook trout, nor did electrofishing of tributaries from Warm Spring to Ice Box Canyon (including lower Amphitheater Creek).

The low number of young-of-year brook trout found in 2008 is another encouraging sign that the electrofishing removal is limiting reproduction and recruitment. The current plan is to continue the annual electrofishing removals, which requires about one week each September for staff from the three agencies. Although the cost is significant, it pales in comparison to the alternative—the loss of Yellowstone cutthroat trout from Soda Butte Creek.

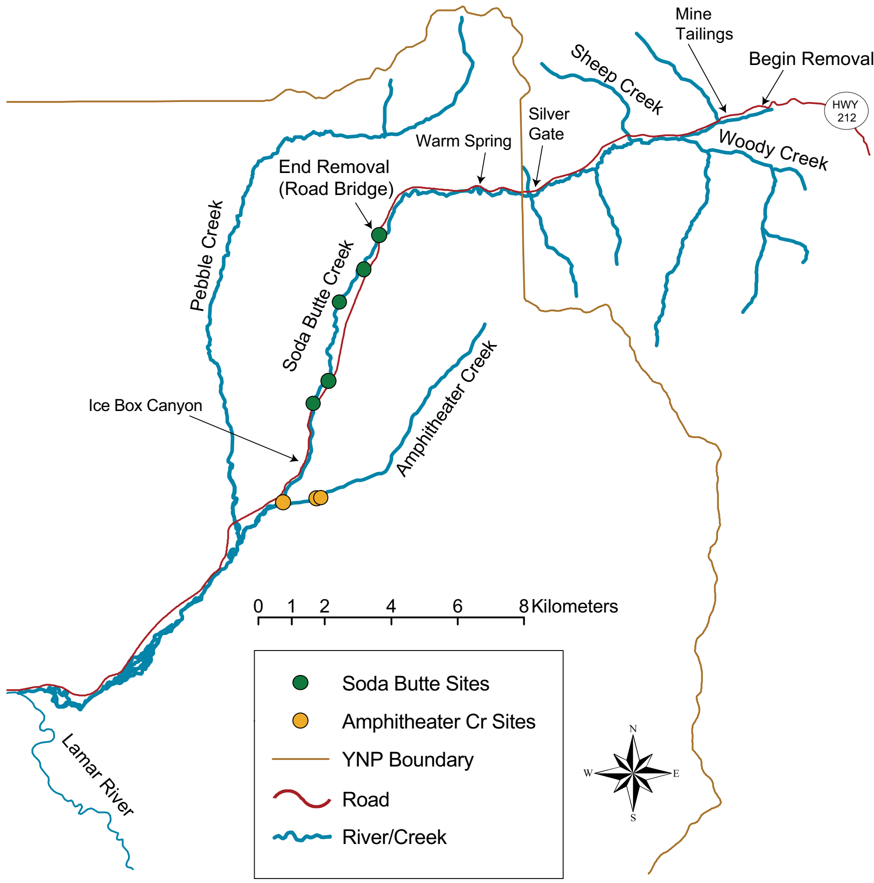


Figure 11. Soda Butte Creek watershed in northeastern Yellowstone National Park and the Gallatin National Forest, including the reach electrofished to remove nonnative brook trout in 2008.

Table 1. Total (and young-of-year only) brook trout mechanically removed from Soda Butte Creek within the Gallatin National Forest, State of Montana, and Yellowstone National Park, 2004–2007.

Removal Reach	2004	2005	2006	2007	2008*
HWY 212 to McClaren Mine Tailings	19(1)	3(0)	0(0)	0(0)	0(0)
McClaren Mine Tailings to Woody Creek	15(0)	17(0)	3(0)	3(0)	2(0)
Woody Creek to Sheep Creek	8(2)	43(0)	16(0)	0(0)	1(0)
Sheep Creek to Silver Gate	251(79)	932(51)	142(6)	45(8)	5(0)
Silver Gate to Yellowstone Park Boundary	9(3)	80(9)	54(2)	48(19)	13(0)
Yellowstone Park Boundary to Warm Spring	7(0)	11(0)	0(0)	50(27)	23(2)
Warm Spring to Road Bridge	0(0)	1(0)	0(0)	0(0)	3(1)
Road Bridge to Ice Box Canyon	–	–	–	–	0(0)
Tributaries	0(0)	17(0)	15(0)	4(0)	1(0)
Total	309(85)	1,104(60)	230 (8)	150(54)	48(3)

* *Data incomplete for 2008 field season.*

Genetic Analyses of Fluvial Cutthroat Trout Populations

Genetic samples from eight sites on six waters were analyzed in 2008 (bold text in Appendices iii and iv). Seven of the sites were sampled during the summer of 2007 and analyzed by Steven Kalenowski at the Montana State University Department of Ecology using the single nucleotide polymorphism (SNP) method. The eighth sample was collected on Last Chance Creek in 2008 and analyzed by Robb Leary at the University of Montana Conservation Genetics Lab. Results of the analyses for Grayling, Last Chance, and Slough creeks are discussed above. Results from the other three waters will be discussed here.

Black Butte Creek, a Gallatin River tributary, was surveyed in 2007 as a potential watershed for westslope cutthroat trout restoration. Its current fish population is highly hybridized and contains more rainbow trout (62%) than westslope cutthroat (37%) alleles and a low level of Yellowstone cutthroat trout alleles (1%; Appendix iv).

Oxbow Creek, a tributary of the Yellowstone River that is connected to Geode Creek in places, was investigated in 2007 to determine if the portion of the creek downstream of Phantom Lake contained a genetically unaltered westslope cutthroat trout population similar to that found in Geode Creek. Results demonstrated that the fish population is a hybrid swarm containing westslope cutthroat trout (75%) and Yellowstone cutthroat trout (25%) alleles. These results imply that the dry reach and road culvert at the Phantom Lake outlet is a barrier to upstream fish movement, as Yellowstone cutthroat trout alleles have not been found in any part of Geode Creek.

Trout Lake, a small lake in the Soda Butte Creek watershed, has one of the oldest stocking histories of any water in the park. Originally stocked with cutthroat trout in 1881, the lake continued to be stocked regularly until 1955 and included both cutthroat trout and rainbow trout (Varley 1981). It was therefore presumed that the lake's trout population was thoroughly hybridized. However, genetic analysis indicates that this may not be the case. Of the 35 fin clips collected by the Fly Fishing Volunteers Program in 2007, 31 were from genetically unaltered Yellowstone cutthroat trout and four were unaltered rainbow trout. In light of this analysis it was determined that additional sampling was needed to understand the population dynamics in Trout Lake. Genetic samples were collected during the spring spawning season and throughout the summer in 2008. Several fish captured along the lakeshore had hybrid characteristics but all of the fish that were captured and observed spawning in the lake inlet stream appeared to be pure Yellowstone cutthroat trout. Analysis of the samples collected will be completed during the winter of 2009 and additional sampling is needed. At present, it appears that a population of genetically unaltered Yellowstone cutthroat trout may inhabit the lake with rainbow trout and their hybrids. If this is the case, the remaining cutthroat trout are at serious risk of becoming hybridized and measures to mitigate for this may be warranted.

NPS/M. RUHL

Rainbow trout from Trout Lake.

NPS/T. KOEL

A cutthroat-rainbow trout hybrid from Grayling Creek.

Piscivorous avifauna (fish-eating birds) like white pelicans are an integral part of the ecology of aquatic systems. They have significant impacts on fish abundance, distribution, and health.

Long-term Water Quality Monitoring

Monitoring water quality continues to be a high priority for Yellowstone, with standardized data available for 17 sites dating back to May 2002. The monitoring is conducted in cooperation with the Vital Signs Monitoring Program of the Greater Yellowstone I & M Network, which includes Yellowstone National Park, Grand Teton National Park (including John D. Rockefeller Jr. Memorial Parkway), and Bighorn Canyon National Recreation Area. In Yellowstone, 12 sites are on major rivers and 7 are on Yellowstone Lake, including two sites added to the program in 2003 (Figure 1). Because stream discharge strongly influences limnological processes, most of the stream sites are located near U.S. Geological Survey discharge gaging stations so that flow-weighted measurements can be calculated for chemical parameters.

The purpose of the long-term water quality program is to acquire baseline information for Yellowstone's surface waters that can be used to evaluate overall ecosystem health, ascertain impacts of potential stressors (e.g., road construction activities or accidental sewage spills), identify any changes that may be associated with water quality degradation, and guide resource management decisions related to water quality. In 2008, data was collected monthly at each monitoring site on core water quality parameters, including water temperature, dissolved oxygen, pH, specific conductance, and turbidity. Water was also collected from each site, filtered, dried and weighed for total suspended solid (TSS), volatile suspended solid (VSS), and fixed suspended solid (FSS) analysis. In addition, 10 of the stream sites were sampled for various chemical parameters, including anions (sulfate, chloride, bicarbonate, and carbonate), cations (calcium, magnesium, sodium, and potassium), and nutrients (total phosphorus, orthophosphate, nitrate, nitrite, and ammonia). Dissolved and total metals (arsenic, copper, iron, and selenium) in water and sediments are also measured twice annually during high and low flow periods on upper Soda Butte Creek at the park boundary near Silver Gate, Montana.

To supplement physical and chemical data, aquatic invertebrates were collected from five stream locations near long-term water quality monitoring sites. Within the Yellowstone River drainage these include two sites on Soda Butte Creek and one site each on the Gardner River, and Reese Creek; within the Madison River drainage invertebrates were collected from one location on the lower portion of the Gibbon River.

All water quality data were entered into the NPSTORET (STOrage and RETrieval) database which is part of the larger, national EPA STORET database and is a repository for water quality, biological, and physical data used by state environmental agencies, the EPA and other federal agencies, universities, and private citizens. The water quality sampling effort in Yellowstone National Park during 2008 comprised a total of 168 site visits and 5,309 results which were entered into NPSTORET. Results included field observations, multiprobe measurements, and laboratory analysis.

Core Water Quality Parameters

In general, physical and chemical characteristics of water quality are related to seasonal changes, elevation, precipitation events, and the presence or absence of thermal features. Statistics for 2008 core water quality parameters indicate spatial trends very similar to those observed from 2002–2007 (Figure 12).

In 2008, 4 of 8 sites monitored in the Yellowstone River drainage of Yellowstone National Park met or surpassed national/state water quality standards for all parameters on all collection days. These include the Yellowstone River at Fishing Bridge and at Corwin Springs, the Gardner River near the park's north entrance, and upper Soda Butte Creek near the park's northeast entrance. The other four sites did not meet the standards outlined by the EPA or state for at least one parameter on at least one visit. Three sites did not meet water quality standards for pH: Yellowstone River at Canyon (4 site visits), Pelican Creek, and lower Soda Butte Creek (1 site visit each) (Figure 12c). One sample visit to the Lamar River site did not meet NPS water quality criteria for turbidity (Figure 12e). The low pH and high turbidity values are likely attributable to natural seasonal variation within the watersheds. In addition, both the Yellowstone River at Canyon and Pelican Creek have a large number of upstream thermal inputs which contribute greatly to the overall acidity of the streams and affect the pH, particularly during low flow periods.

The Madison River drainage, located in the western portion of the park, is dominated by geothermal activity, with the Upper, Biscuit, and Midway geyser basins in the upper reaches of the Firehole River and the Norris Geyser basin adjacent to the Gibbon River (Figure 1). As a result, water entering this drainage varies considerably in temperature, acidity, and

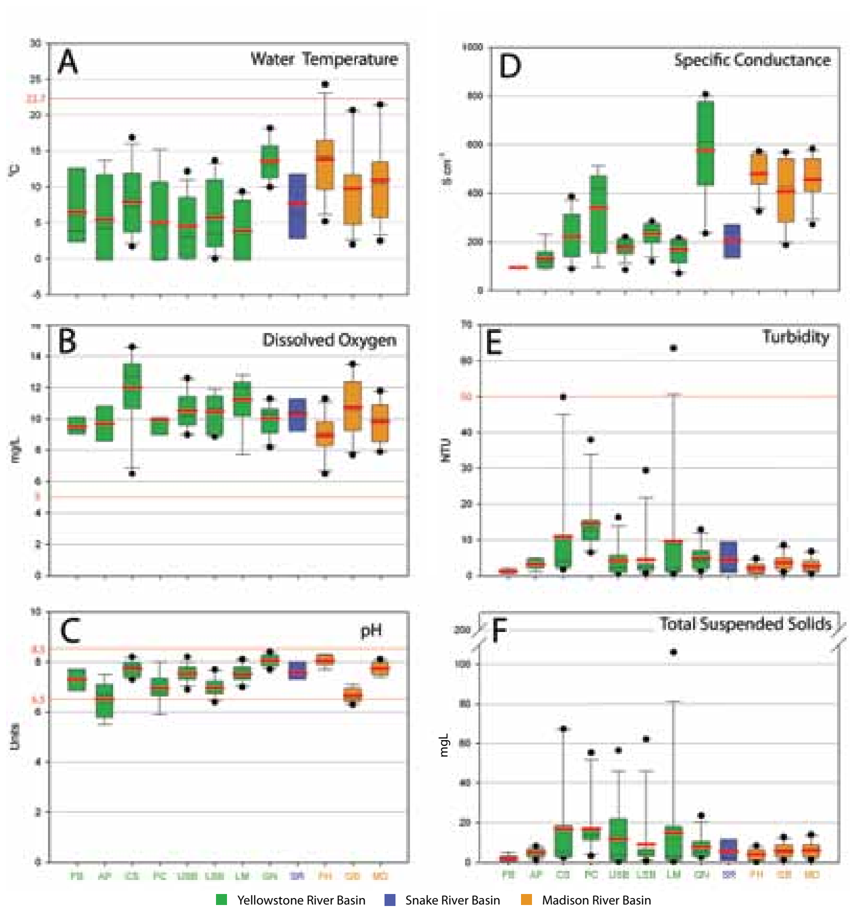


Figure 12. Box and whisker plot illustrating annual variation for selected parameters at each water quality location. Lower and upper portions of boxes represent the 25th and 75th percentile, respectively: lower and upper black horizontal bars represent 10th and 90th percentile, respectively. Outlying values are represented by black dots; means are indicated by solid red lines. (YFB = Yellowstone River at Fishing Bridge, YCN = Yellowstone River at Canyon, YCS = Yellowstone River at Corwin Springs, PC = Pelican Creek, USB = upper Soda Butte Creek, LSB = lower Soda Butte Creek, LM = Lamar River, GN = Gardner River, SR = Snake River, FH = Firehole River, GB = Gibbon River, and MD = Madison River). (*) = indicates sites with geothermal contributions. Snake River is not sampled during winter months.

dissolved ions. Although the water quality site on the Madison River met or surpassed national/state water quality standards for all parameters on all collection days in 2008, the other two sites in this drainage each fell short of the standards in one sample. The July sample from the Firehole River exceeded water temperature criteria (22.7°C) established by Yellowstone National Park management for guiding fishing restrictions (Figure 12a); and one sample from the Gibbon River fell below the minimum pH of 6.5 standard units. The pH values in both the Firehole and Gibbon rivers are a result of local geology and thermal activity. Because of this, aquatic life has adapted to these conditions and they are unlikely to have long-term, negative effects on water quality, aquatic biota, or recreational use within this portion of the park.

Water quality on the Snake River at Flagg Ranch, which is monitored by both Yellowstone and Grand Teton national parks, met or surpassed EPA/state standards for all core water quality parameters during 2008.

Chemical Constituents of Surface Waters

Aquatic plants and animals use dissolved chemicals to varying degrees for basic cellular structure, metabolism, growth, and development. In Yellowstone, dissolved concentrations of ions and nutrients are most closely related to natural factors such as geology, discharge, geothermal input, grazing, and uptake by aquatic plants, but there are also anthropogenic sources such as sewage spills, runoff from paved road surfaces, and acid mine drainage. Generally, dissolved ion concentrations in Yellowstone waters are relatively low compared to other surface waters, especially in the spring during high runoff; higher concentrations are recorded in the fall and winter during low flow conditions.

The park's water quality monitoring program was expanded to include select anions, cations, and nutrients starting in May 2006. Percent concentrations of major anions and cations in 2008 were very similar to those of 2007. Relative concentrations of major anions and cations were calculated for each site and

NPS/J. SKORUPSKI

This Northern Range wetland was surveyed for amphibians.

distinct patterns of relative dissolved ion concentrations were observed in the Yellowstone and Madison drainages (Figure 13). For the most part, the most abundant ion was bicarbonate $Ca(HCO_3^{2-})_2$, but concentrations of other major ions varied among watersheds. The Lamar River drainage, within the Yellowstone River basin, had higher concentrations of calcium (Ca^{2-}) ions than the Yellowstone River mainstem, which

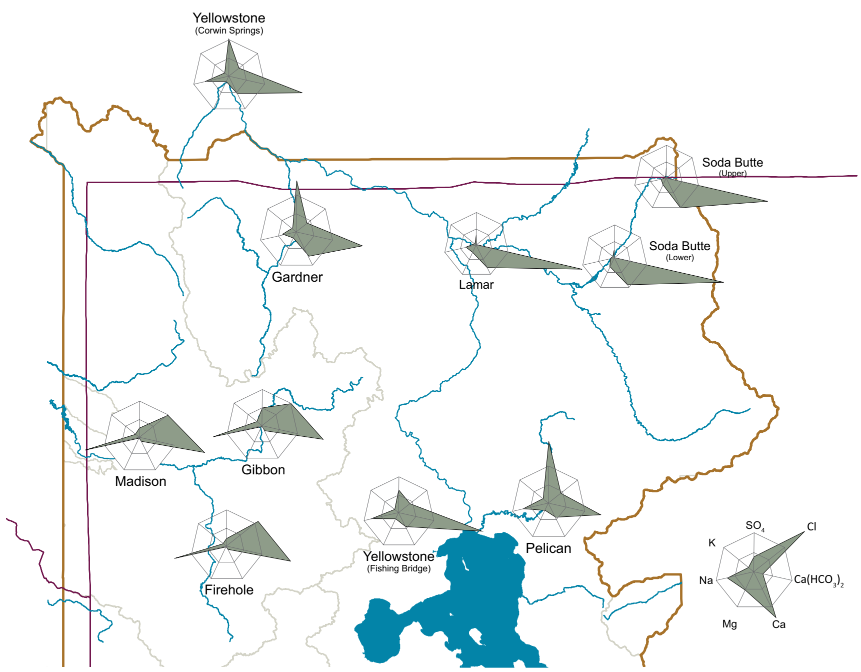


Figure 13. Average annual percent ion concentration of seven measured ions from water quality sites on rivers and streams in Yellowstone National Park. The concentric heptagons represent the 10th and 20th percentiles respectively from the center with remaining percentiles not shown. (SO_4 = sulfate, Cl = chloride, $Ca(HCO_3)_2$ = bicarbonate, Ca = calcium, Mg = magnesium, Na = sodium, K = potassium).

NPS/T. KOEL

Spawning cutthroat trout it the inlet stream at Trout Lake.

had higher concentrations of sulfate (SO_4^{2-}). In addition to bicarbonate ions, both sodium (Na^+) and chloride (Cl^-) were present in approximately equal proportions in the Madison River basin (Figure 13). Both phosphorus and nitrogen concentrations were very low for all sites sampled. Mean total phosphorus concentrations were highest on the Firehole River (0.21 mg/L, with a range between 0.13 and 0.36 mg/L). Orthophosphate, nitrate, nitrite, and ammonia were very low; most concentrations were below the analytical detection limit. If a strong correlation emerges among sites and between years, this will improve our ability to detect changing water quality conditions as monitoring continues.

Regulatory Monitoring on Soda Butte Creek and Reese Creek

Two stream segments at the Yellowstone National Park boundary are listed as 303(d) impaired by the state of Montana and are monitored as regulatory streams: upper Soda Butte Creek near Cooke City and Reese Creek near Gardiner. In-stream metals contamination in Soda Butte Creek is a result of historical mining in the vicinity of Cooke City, which is approximately 8 kilometers from the park boundary. Mine tailings persist within the floodplain of Soda Butte Creek and contribute to the impaired listing of a portion of this stream that only partially supports aquatic life and cold water fisheries. At the upper Soda Butte Creek site, water and sediment samples are analyzed for arsenic, copper, iron, and selenium during both high- and low-flow conditions, which occur in June and September respectively. The EPA/state standard for dissolved iron, 1 mg/L (chronic), was exceeded during one site visit in September 2008 (1.87 mg/L).

Water-use and water-rights issues at Reese Creek are also a concern for park managers. Discharge measurements are collected from two locations: just above the uppermost flume and stream water flowing through the upper diversion ditch. The amount of water entering the main channel from the uppermost flume is the difference between these two readings. The adjudicated water rights stipulate that Reese Creek is to have a minimum flow of 1.306 ft^3/sec from April 15 to October 15 every year. During 2008, discharge on Reese Creek ranged from 5.57 to 18.88 ft^3/sec. Continued monitoring of discharge during the summer is important to conserve the stream's populations and biological integrity.

Yellowstone Lake Limnology

Understanding the limnology of Yellowstone Lake, the park's most prominent body of water, is an important part of comprehending the ecology of lake trout and carrying out the lake trout suppression program. Water temperature, dissolved oxygen, specific conductance, and turbidity measurement were sampled monthly from May through October 2008 at seven sites in the Yellowstone Lake basin (Figure 1). Weather permitting, temperature profile data were also collected from the West Thumb and South Arm. Water samples were collected at each location for analysis of total suspended solids (TSS), volatile suspended solids (VSS) and fixed suspended solids (FSS). In 2009, water quality sampling on Yellowstone Lake will increase to twice monthly to better capture changes in water quality conditions during the summer. Additionally, temperature data loggers will be placed at regular depth intervals in the West Thumb to better understand changes in the temperature profile throughout the summer and fall.

NPS/J. SKORUPSKI

A mayfly from the family Ephemeroptera.

Macroinvertebrates Surveys

Aquatic invertebrates are an important element in aquatic food webs and include a wide assortment of feeding groups: primary consumers (filter feeders, herbivores, scrappers, and shredders); predators that feed on other invertebrates; larval amphibians; and young fish. In turn, the various life stages of these invertebrates provide an important food source for fish, birds, and mammals. Aquatic invertebrate sampling is used to supplement long-term water quality data, evaluate the impact of road construction activities on aquatic resources, and assess the impacts that our fish restoration activities have on non-target aquatic organisms. Aquatic invertebrates are ideal biologic indicators because they live 1–2 years and are relatively immobile and sensitive to environmental changes. Stream invertebrates in the three groups known as EPT taxa—Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)—are a major component of fish diets and generally less tolerant of environmental stressors than are other aquatic invertebrate groups. Since EPT taxa are sensitive to changing environmental conditions, their relative abundance is correlated with good water quality. Conversely, aquatic invertebrates that belong to the insect order Diptera (true flies) are more tolerant of environmental stressors, with higher densities usually indicating poorer water quality or environmental stress. By assessing these aquatic invertebrate groups we can predict the overall impacts that potential stressors may have on aquatic systems.

In 2008, 24 invertebrate sites were surveyed on 15 stream segments. Five of these sites were sampled as part of our long-term water quality monitoring program (discussed above), 6 sites were associated with road construction projects, and 13 sites were located within current or proposed native fish restoration watersheds. During August 2008, CFT Legumine formulation (rotenone) was used to remove nonnative fish from the East Fork Specimen Creek drainage. Pre- and post-treatment aquatic invertebrate surveys were conducted to assess the piscicide's impact on the stream invertebrate community. The invertebrate samples were sent to an independent contractor for analysis; the results will be available in 2009.

Amphibian Surveys

Yellowstone National Park is home to four amphibian species: the Columbia spotted frog (*Rana luteiventris*), the boreal chorus frog (*Pseudacris maculata*), the boreal toad (*Bufo boreas*), and the blotched tiger salamander (*Ambystoma tigrinum*) (Koch and Peterson 1995). In June and July 2008, we investigated 60 wetlands identified by the National Wetlands Inventory (U.S. Fish and Wildlife Service 1998)

NPS/T. KOEL

Naturally high turbidity occurs in this pond (pond #33), home to a translucent variety of blotched tiger salamander larvae.

for the presence of amphibians in areas targeted for native trout restoration. Most of these wetlands were on the park's northern range (57 sites); the other 3 were in the East Fork Specimen Creek drainage in the vicinity of High Lake.

The northern range surveys focused on the Blacktail Deer and Elk creek drainages with 29 and 26 sites surveyed, respectively. After several years of sampling within these watersheds, wetland selection and surveys were primarily based on the wetland's potential for holding water and serving as a breeding/foraging area for amphibians. Of the 55 wetlands surveyed in the northern range, 33 provided habitat that met these criteria. Adults of all four amphibian species were found within the survey areas. Evidence of breeding (larvae and/or egg masses) was documented at 19 sites, 10 of which contained at least two species. Blotched tiger salamanders were found to breed at 15 sites, boreal chorus frogs at 11 sites, and Columbia spotted frogs at 6 sites. Adult boreal toads were observed on the northern range, but no breeding activity was documented. This species is more common in the Gibbon and Firehole river drainages, where it breeds in thermally influenced wetlands.

Three wetlands in the upper reaches of East Fork Specimen Creek were surveyed for amphibians in July 2008. This area was the initial site of our Specimen Creek native fish restoration project in which nonnative fishes were chemically removed from High Lake during August 2006. Chemical removal of fishes can have adverse affects on non-target organisms such as amphibians and aquatic invertebrates. Prior to treatment, amphibians were found to breed in High Lake and two adjacent wetlands. Columbia spotted frogs were documented breeding at all three sites, while boreal chorus frogs bred at one site. Larval tadpoles from High Lake were only documented in the lake outlet where the water is typically shallow and dominated by sedges. Treatment of High Lake had adverse impacts on larval amphibians, resulting in what appeared to be 100% mortality. Subsequent sampling in 2007 and 2008 documented Columbia spotted frog tadpoles were present around the entire lake margin rather than just in the lake outlet. This was probably due to the lack of fish predation during the two years following fish removal.

The wetland surveyed near the confluence of Slough Creek and the Lamar River had larval blotched tiger salamanders lacking most skin pigments. On July 14, 2008, we documented very high turbidity (1,488 NTU), high specific conductance (3,109 S cm^{-1}), a high pH (8.9 SU), sparse submersed aquatic vegetation, and very few aquatic invertebrate taxa at this site. Further analysis of water chemistry from this site indicated high sodium (608 mg/L), sulfate (294 mg/L), and bicarbonate (2,040 mg/L) concentrations, which are atypical for this watershed.

NPS

This blotched tiger salmander larvae lacks most skin pigment and is highly translucent. It was sampled from pond 33, near the confluence of the Lamar River and Slough Creek on Yellowstone's Northern Range.


NPS/T. KOEL

Visitors, like these in Slough Creek, submit Volunteer Angler Reports about fish and fishing in the park.

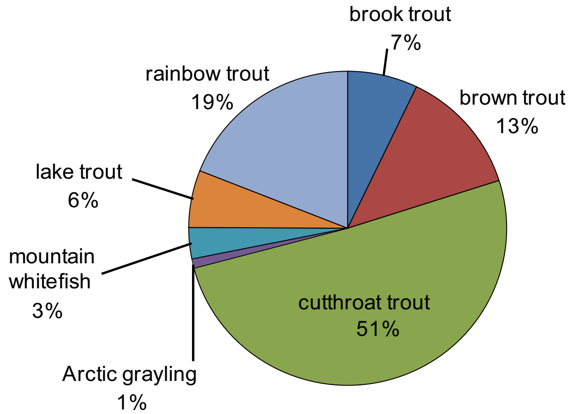


Figure 14. Percentage of each species in parkwide, angler-reported catch during the 2008 fishing season.

Trends from Volunteer Angler Report Cards

Angling remains a popular pastime for those visiting, living near, and working in Yellowstone National Park. Of the 3.1 million visitors to the park in 2008, 48,284 obtained the special use permit required for fishing in park waters and received a volunteer angler response (VAR) card. These cards, which have been handed out since 1973, provide anglers an opportunity to share their experience and opinions about Yellowstone fishing with park managers. Almost 2,500 usable angler outings were added to the database from VAR responses in 2008. Exit gate surveys in which visitors are interviewed as they leave the park provide managers with additional information about visitors' fishing. In 2008, these surveys revealed that nearly 2.6% of anglers who purchased a fishing permit did not fish, while 0.4% of visitors fished without a permit; this resulted in an estimate of 47,223 anglers fishing during the 2008 season.

Parkwide angler use (total number of days anglers spent fishing) was 268,444 days in 2008, a 31% decrease from 2007, though similar to 2006 angler use. It is estimated that anglers landed 699,532 fish and creeled 30,250, releasing more than 95% of fish caught. Anglers fished for an average of 2.82 hours a day during a typical outing and fished 1.66 days during the season. Of the anglers who typically fished only one day (66% of all anglers), 77% caught fish. Anglers reported being satisfied with the overall fishing experience (78%), with the number of fish caught (63%) and with the size of fish (66%) in 2008, representing little change from previous years.

Of the 19,901 fish for which length was reported in 2008, the mean length was 11.9 inches, 45.9% of these fish were greater than 12 inches and 30.1% were greater than 14 inches. Lake trout had the greatest average length (17.3 in., a 0.2 in. decrease from 2007), followed by whitefish (12.6 in., 0.5 in. increase) and cutthroat trout (12.6 in., 0.7 in. increase), brown trout (11.3 in., no change), rainbow trout (10.4 in., 0.3 in. increase), grayling (8.5 in., 1.4 in. decrease) and brook trout (7.4 in., 0.1 in. decrease). Compared to 2007, average length increased most for cutthroat trout (0.7 in.) and decreased most for grayling (1.4 in.).

Native cutthroat trout remained the most sought-after species again in 2008, comprising 51% of all fish caught (Figure 14). Rainbow trout were the second most abundantly caught species comprising 19% of angler catch, followed by brown trout (13%), brook trout (7%), lake trout (6%), mountain whitefish (3%), and Arctic grayling (1%). Native fish species (cutthroat trout, whitefish and grayling) comprised 55% of all fish caught.

Yellowstone Lake remained the most popular destination for anglers. An estimated 6,873 anglers fished Yellowstone Lake in 2008, which is approximately one out of every seven anglers fishing in the park. Anglers caught an estimated 68,046 cutthroat trout in Yellowstone Lake in 2008, a decrease from 2007, but similar to 2006 numbers. The angler reported catch of cutthroat trout was 0.73 fish per hour in 2008, a higher catch rate than the previous three years (Figure 15). The average size of cutthroat trout reported by anglers decreased slightly in 2008 to 437mm, (17.2 in.) due to an increase of cutthroat trout in the 12–16 inch size classes rather than a decrease of larger fish (Figure 16a).

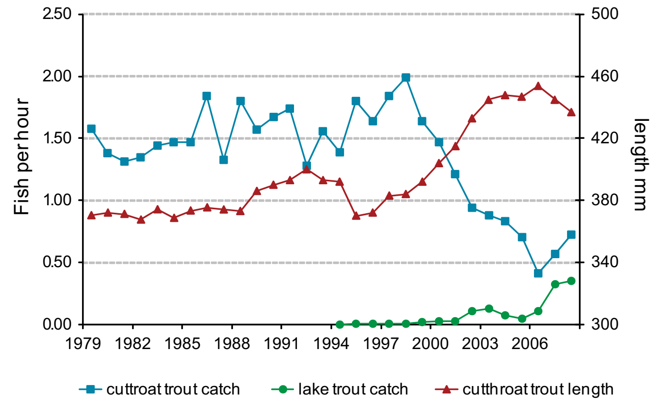


Figure 15. Angler-reported catch rates of Yellowstone cutthroat trout and lake trout and the mean length of angler-reported cutthroat trout caught on Yellowstone Lake in 2008.

The estimated angler catch of lake trout in Yellowstone Lake decreased by almost 15,000 in 2008 to 32,981 fish. However, lake trout in the 14–20 inch size classes were reportedly caught much more frequently than in any previous year (Figure 16b).

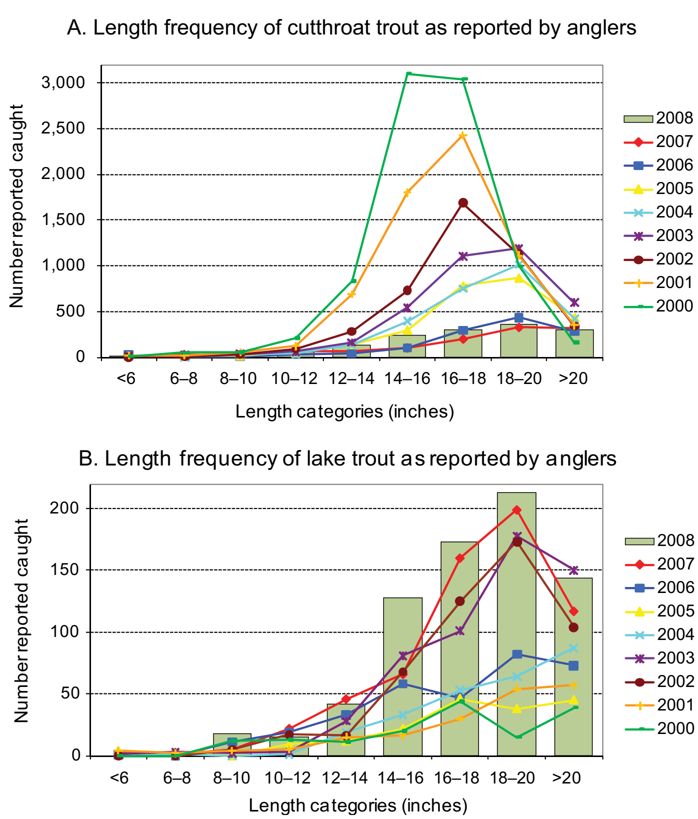


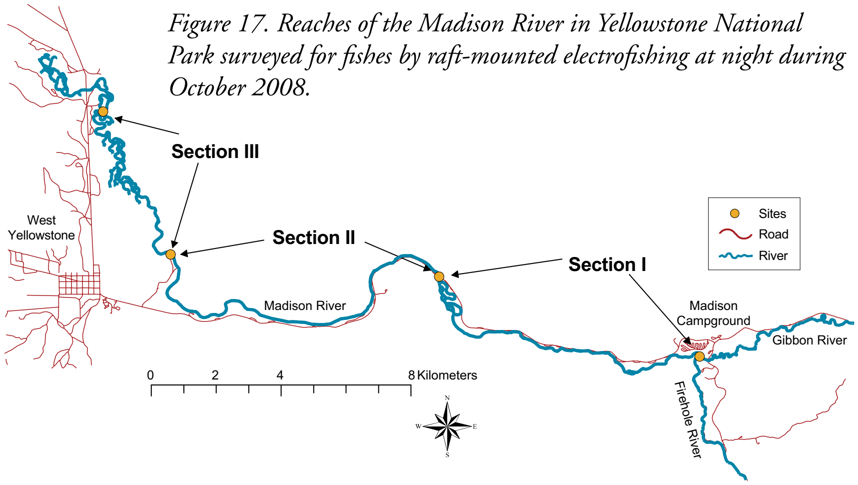
Figure 16. Percentage of angler-reported catch among length classes for (A) Yellowstone cutthroat trout and (B) lake trout from Yellowstone Lake, 2000–2008.

Madison River Fishery Survey

Within the park, the Madison River is managed under wild trout enhancement area regulations which permit only fly-fishing and mandate release of mountain whitefish, brown trout, and rainbow trout. Since the last assessment was done in 1989, the only information available on the Madison River fishery has been from VAR census cards, which can be used to determine annual catch rates and average fish size. Given its popularity among anglers, a more intensive assessment of the fishery was deemed necessary. With assistance from the Gallatin National Forest, sampling was conducted in October 2008 during the spawning migrations of all species so that population size estimates would include fish migrating into the park from the Hebgen Reservoir. The goals of the project were to determine (1) the abundance of brown trout, rainbow trout, and mountain whitefish in this section of the Madison River, (2) the upstream extent of movement of these species during their spawning migrations, and (3) the age structure of the populations.

We used a sampling design that split the river into three sections of approximately equal distance: section I was from the confluence to 7-Mile Bridge, section II from 7-Mile Bridge to Barnes Hole, and section III from Barnes Hole to Bakers Hole Campground on the park's west boundary (Figure 17). Fish were collected using a 15-foot raft outfitted with electrofishing equipment. All captured mountain whitefish, brown trout, and rainbow trout were measured for length, weighed (nearest 10 grams), and fin clipped (anal, left pelvic, or right pelvic) for identification purposes. Scale samples were taken from up to 10 fish in each 20 mm size category for each species. Fish marked with a tag or clip by Montana Department of Fish, Wildlife and Parks staff operating a fish weir downstream were also noted.

Figure 17. Reaches of the Madison River in Yellowstone National Park surveyed for fishes by raft-mounted electrofishing at night during October 2008.



We sampled 36 km of the Madison River over seven nights (October 13–19) and captured approximately 50 fish/km (1,594 brown trout, 464 rainbow trout, and 1,323 mountain whitefish) during two electrofishing passes over all three sections. Point estimates indicated 692 mountain whitefish, 534 brown trout, and 268 rainbow trout per kilometer. Population estimates were calculated using the Petersen equation with the Chapman modification. Brown trout were the most abundant species in section I, there was an almost equal number of brown trout and mountain whitefish in section II, and whitefish were most abundant in section III (Figure 18; Table 2). Rainbow trout were the largest fish captured, averaging 369.9 mm in total length (Table 3). Fish of each species were found in both pre- and post-spawning condition in all sections of the river, although section III contained the majority of spawning whitefish. Results of our initial survey indicate healthy populations of the three species.

NPS/B. CROWLEY

A brown trout caught on the Madison River.

NPS/K. OLSEN

Raft outfitted with electrofishing equiptment.

Table 2. Abundance estimates for mountain whitefish, brown trout, and rainbow trout in three study sections in the Madison River, Yellowstone National Park, Wyoming.

Species	Estimate Type	Section I	Section II	Section III
Mountain whitefish	Point Estimate (N)	4,022	6,424	14,461
	95% Confidence Interval	1,451–7,910	1,920–11,191	8,550–23,938
Brown trout	Point Estimate (N)	8,117	6,426	4,663
	95% Confidence Interval	5,527–11,853	2,613–12,852	2,314–8,741
Rainbow trout	Point Estimate (N)	5,693	1,452	2,502
	95% Confidence Interval	1,702–9,917	298–1,513	903–4,921

Table 3. Mean total length (mm) of mountain whitefish, brown trout, and rainbow trout sampled in the Madison River, Yellowstone National Park, Wyoming and Montana.

Species	Section	N	Mean TL (mm)	Range (mm)
Mountain whitefish	I	218	345.6	141–422
	II	232	300.2	133–446
	III	873	342.3	41–510
	Total	1,323	330.1	41–510
Brown trout	I	901	339.1	95–603
	II	319	361.4	120–645
	III	374	427.6	102–670
	Total	1,594	364.3	95–670
Rainbow trout	I	212	366.5	115–514
	II	75	353.1	115–511
	III	177	381.0	80–540
	Total	464	369.9	80–540

NPS/B. CROWLEY

A rainbow trout sampled in the Madison River during an abundance estimate survey in October 2008.

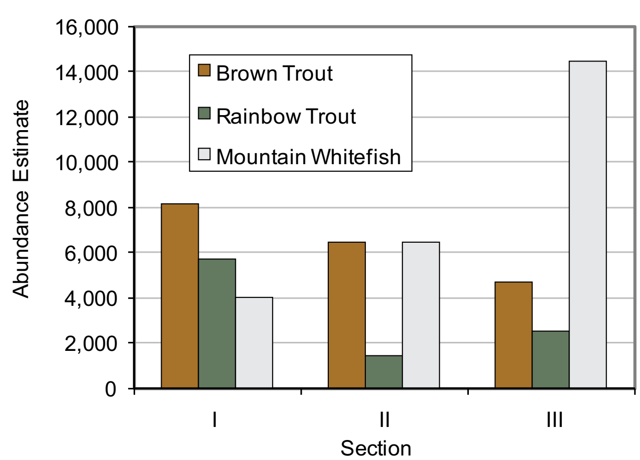


Figure 18. Estimated abundances of brown trout, rainbow trout, and mountain whitefish in three reaches of the Madison River in Yellowstone National Park, October 2008.


NPS/W. VOIGT

Volunteer anglers hiking in to Elk Creek.


NPS/W. VOIGT

Volunteer anglers in upper Slough Creek.

Seventh Year of Fly Fishing Volunteers

The Fly Fishing Volunteers program assisted with the Specimen Creek westslope cutthroat trout restoration by capturing trout at several locations in the lower portion of the drainage. The volunteers also focused on sample collection for cutthroat trout genetics, including distribution of pure and hybridized fish in Slough Creek and Soda Butte Creek, and in Trout Lake, where both Yellowstone cutthroat trout and nonnative rainbow trout currently exist. A bedrock waterfall on Grayling Creek and a long cascade on lower Elk Creek were investigated to determine if either feature could block upstream movement of fish. Both of these streams provide excellent opportunities for cutthroat trout restoration.

Throughout the 2008 field season, 89 volunteers participated in the program, contributing 1,885 hours to the park's fisheries. As in past years, the volunteers indicated that the experience they had was very positive, and were very happy that they could participate in such a program and contribute to Yellowstone fisheries.

Long-term Volunteer Assistance

The Fisheries Program recruits volunteers through the Student Conservation Association (SCA) and other sources (see Appendix v) to stay in park housing at Lake or Mammoth for twelve or more weeks and work a full-time schedule. Typically, two groups of SCA volunteers participate: the first from mid-May through early August, and the second from early August through late October. Our goal is to have the volunteers gain experience with as many Fisheries Program activities as possible. Given that 10,000s of hours of assistance have been provided by volunteers over the years, there is no question that all aspects of our program have greatly benefited from both long- and short-term volunteer support.

Educational Programs

Fisheries Program staff continued to provide a variety of short-term educational programs for visiting schools and other interested groups, with an emphasis on native fish conservation. Park staff also provided American Red Cross first aid and CPR certification for fisheries employees and volunteers.

Collaborative Research

The Fisheries Program, through the Yellowstone Center for Resources, provides both direct and indirect support for collaborative research with scientists at other institutions, primarily universities. These studies address some of the most pressing issues faced by NPS biologists and other regional managers of aquatic systems.

Projects by Graduate Students

Graduate student: Julie Alexander (Doctor of Philosophy candidate).
Committee co-chairs: Drs. Billie Kerans and Todd Koel, Department of Ecology, Montana State University.
Title: Detecting *Myxobolus cerebralis* infection in *Tubifex tubifex* of Pelican Creek.
Status: Field studies completed, lab work, analyses, and writing on-going.

Graduate student: Patricia Bigelow (Doctor of Philosophy candidate).
Committee chair: Dr. Wayne Hubert, U.S. Geological Survey, Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming.
Title: Predicting lake trout spawning areas within Yellowstone Lake, Wyoming.
Status: Field studies completed, analyses, and writing on-going.

Graduate student: Hilary Billman (Master of Science candidate).
Committee chair: Dr. Charles Peterson, Department of Biological Sciences, Idaho State University.
Title: Effects of fish restoration on amphibian populations in Yellowstone National Park and southwestern Montana.
Status: Field studies initiated.

Graduate student: Brian Ertel (Master of Science candidate).
Committee chair: Dr. Thomas McMahon, Department of Ecology, Montana State University.
Title: Distribution, movements, and life history of Yellowstone cutthroat trout in the upper Yellowstone River basin.
Status: Field studies completed, lab work, analyses, and writing on-going.

Graduate student: Lynn Kaeding (Doctor of Philosophy candidate).
Committee chair: Dr. Daniel Goodman, Department of Ecology, Montana State University.
Title: Comprehensive analysis of historic and contemporary data for the cutthroat trout population of Yellowstone Lake.
Status: Analyses and writing on-going.

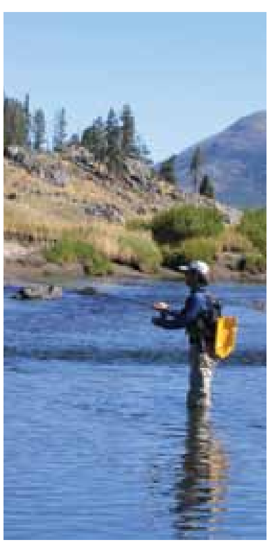
Graduate student: John Syslo (Master of Science candidate).
Committee chair: Dr. Christopher Guy, U.S. Geological Survey Cooperative Fisheries Research Unit, Department of Ecology, Montana State University.
Title: Lake trout suppression program data analysis, modeling, and guidance to improve efficiency.
Status: Analyses and writing on-going.

Interagency Workgroups

Yellowstone National Park actively participates in the Yellowstone Cutthroat Trout Interstate Workgroup, the Montana Cutthroat Trout Steering Committee, and the Fluvial Arctic Grayling Workgroup. Shared goals and objectives among partner agencies and non-governmental organizations are defined in a memorandum of agreement for the rangewide conservation and management of Yellowstone cutthroat trout, a memorandum of understanding (MOU) and conservation agreement for westslope cutthroat trout and Yellowstone cutthroat trout in Montana (http://fwp.mt.gov/wildthings/concern/yellowstone.html), and an MOU concerning the recovery of fluvial Arctic grayling (http://fwp.mt.gov/wildthings/concern/grayling.html).

Cutthroat Trout Broodstock Development

The park has verified two genetically unaltered westslope cutthroat trout populations. In 2008 gametes from the population located in Last Chance Creek were incorporated into the upper Missouri River westslope cutthroat trout broodstock at the Sun Ranch in the Madison Valley, Montana.



NPS/W. VOIGT

A volunteer angler in the second meadow of Slough Creek.

NPS/W. VOIGT

A suspected rainbow-cutthroat hybrid from Specimen Ck.

Aknowledgements

Much appreciated administrative support for the Fisheries Program in 2008 was provided by Barbara Cline, Montana Lindstrom, Melissa McAdam, and Becky Wyman. We also appreciate the support and guidance for our cutthroat trout restoration activities from Lee Nelson, Don Skaar, and Ken Staigmiller, Montana Fish, Wildlife and Parks; and Dale White, Gallatin National Forest. Special thanks to Jim Magee and Austin McCullough of Montana Fish, Wildlife and Parks for helping us determine the suitability of upper Grayling Creek for fluvial Arctic grayling.

Diane Eagleson and John Varley of the Big Sky Institute, Montana State University, have graciously provided essential staff support for stream resident cutthroat trout restoration, as well as support for the Yellowstone Lake Science Panel workshop.

Cathie Jean and the Greater Yellowstone Network have been instrumental in the development and funding of the park's water quality monitoring program.

Many other people from within Yellowstone National Park contributed to the success of Fisheries Program activities in 2008; unfortunately, we cannot mention them all here. However, we would like to especially thank Ben Cunningham, Dave Elwood, Tim McGrady, Travis McNamara, Alison Schyler, and Wally Wines from Corral Operations; Wendy Hafer from the Fire Cache; Phil Anderson, Greg Bickings, Earl McKinney, Bruce Sefton, Art Truman, Mark Vallie, Lynn Webb, and Dave Whaley from the Lake Garage; Dan Reinhart from Resource Management; Rick Fey, Brad Ross, and Kim West from the South District Rangers; and Bonnie Gafney, Michael Keator, and Jessica Knoshaug from the West District Rangers. Randy and Sharon Nador served as West District VIPs and greatly assisted with operations at Specimen Creek.

Special thanks to our dedicated fisheries technicians and volunteers for their contributions to our program (see Appendices). The accomplishments of 2008 would not have occurred without your hard work and tireless efforts!

The Student Conservation Association (SCA) and Montana Conservation Corps (MCC) have allowed for the incorporation of many people into the day-to-day activities of the Fisheries Program. Our projects would not be completed without the dedicated support of SCA and MCC.

The Fisheries Program is supported through Yellowstone Center for Resources base funding and a portion of the fees collected from anglers who purchase fishing permits. In 2008, additional funding was received from these sources:

- The Yellowstone Park Foundation, through the Fisheries Fund Initiative and Fly Fishing Volunteer Program
- The Yellowstone Association
- The Whirling Disease Initiative of the National Partnership for the Management of Wild and Native Coldwater Fisheries
- The Inventory and Monitoring Program and Vital Signs Monitoring Program of the National Park Service
- The Recreational Fee Demonstration Program of the Federal Lands Recreation Enhancement Act
- The Greater Yellowstone Coordinating Committee
- The Park Roads and Parkways Program of the Federal Highway Administration

We would like to extend special thanks to the Yellowstone Park Foundation board and staff, and to the many private individuals who have graciously provided support for our critical fisheries projects in the park.

This report is made possible only by the dedicated work of the Science Communication Office, Yellowstone Center for Resources. Special thanks to Tami Blackford, Mary Ann Franke, and Janine Waller for making this report a reality.

NPS/T. KOEL

Staff prepare equipment for transport to the barrier site.

NPS/T. KOEL

From top: Tim McGrady packs a mule; Kate Olsen waits out the rain during a storm at the barrier construction site; Rich and Evan Teer of Intermountain Restoration Inc., and fisheries technician Derek Rupert work to complete contstruction of the barrier.

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Appendices

Appendix i. Fish Species List

Native (N) and introduced (nonnative or exotic, I) fish species and subspecies known to exist in Yellowstone National Park waters including the upper Missouri River (Missouri, Madison, and Gallatin rivers), Snake River (Snake), and Yellowstone River (Yell R.) drainages.

Family	Common Name	Scientific Name	Status	Missouri	Snake	Yell R.
Salmonidae	Yellowstone cutthroat trout	*Oncorhynchus clarki bouvieri*	Native	I	N	N
	westslope cutthroat trout	*Oncorhynchus clarki lewisi*	Native	N		
	finespotted Snake River cutthroat trout	*Oncorhynchus clarki behnkei**	Native		N	
	rainbow trout	*Oncorhynchus mykiss*	Nonnative	I	I	I
	mountain whitefish	*Prosopium williamsoni*	Native	N	N	N
	brown trout	*Salmo trutta*	Exotic	I	I	I
	eastern brook trout	*Salvelinus fontinalis*	Nonnative	I	I	I
	lake trout	*Salvelinus namaycush*	Nonnative		I	I
	Arctic grayling	*Thymallus arcticus montanus*	Native	N		I
Catostomidae	Utah sucker	*Catostomus ardens*	Native		N	
	longnose sucker	*Catostomus catostomus*	Native			N
	mountain sucker	*Catostomus platyrhynchus*	Native	N	N	N
Cyprinidae	lake chub	*Couesius plumbeus*	Nonnative			I
	Utah chub	*Gila atraria*	Native	I	N	
	longnose dace	*Rhinichthys cataractae*	Native	N	N	N
	speckled dace	*Rhinichthys osculus*	Native		N	
	redside shiner	*Richardsonius balteatus*	Native		N	I
Cottidae	mottled sculpin	*Cottus bairdi*	Native	N	N	N

* Scientific name suggested by Behnke (2002), *Trout and Salmon of North America* (New York: The Free Press), and not currently recognized by the American Fisheries Society.

Westslope cutthroat trout, first described by Lewis and Clark, are native to the upper Missouri River, as well as the Gallatin and Madison rivers in the northwest corner of Yellowstone National Park.

Appendix ii. The Waters of Yellowstone (adapted from Varley and Schullery, 1998)

Size of the park	898,318 hectares
Water surface area	45,810 hectares (5% of park)
Number of lakes	150
Lake surface area total	43,706 hectares
Number of fishable lakes	45
Yellowstone Lake surface area	36,017 hectares
Number of streams	>500
Stream length total	4,265 kilometers
Stream surface area total	2,023 hectares
Number of fishable streams	>200

Appendix iii. Genetic Analysis–Yellowstone cutthroat trout

Water	Location (US/DS=up/downstream)	# of Samples	Individuals (%) YCT	Individuals (%) CTX*	Individuals (%) RBT	Allele Frequency (%) YCT	Allele Frequency (%) WCT	Allele Frequency (%) RBT	Year Collected	Year Analyzed	Lab
Amphitheater Creek	DS of waterfall	8	86	14	0	96	0	4	2005	2007	IDFG
Arnica Creek		22	100	0	0	100	0	0	1993	1993	UM
Antelope Creek	US of waterfall	40	100	0	0	100	0	0	2006	2007	IDFG
Antelope Creek	DS of waterfall; US of canyon	40	100	0	0	100	0	0	2006	2007	IDFG
Chipmunk Creek		13	100	0	0	100	0	0	1990	1990	UM
Crystal Creek	near confluence w/Lamar River	7	14	86	0	76	0	24	2005	2007	IDFG
Electric Creek	near confluence w/Reese Creek	9	100	0	0	100	0	0	2005	2007	IDFG
Lamar River	lower	25				99	0	1	1993	1993	UM
Lamar River	at Cache Creek	25	100	0	0	100	0	0	1993	1993	UM
Lamar River	at Flint Creek	25	100	0	0	100	0	0	1993	1993	UM
Lamar River	at Calfee Creek	25	100	0	0	100	0	0	1993	1993	UM
Lamar River	near Slough Creek confluence	37				64	1	35		2006	BYU
Lamar River	Lamar River Canyon	10				90	0	10		2006	BYU
Lamar River	confluence w/Soda Butte Creek	8				97	0	3		2006	BYU
Lamar River	US from confluence w/ Soda Butte Creek	7	100	0	0	100	0	0		2006	BYU
Lamar River		10	100	0	0	100	0	0		2006	BYU
Lamar River	across from Geyser Basin	30				98	0	2		2006	BYU
Lamar River	at bridge to Soda Butte Creek	10				98	0	2		2006	BYU
Mist Creek		26	100	0	0	100	0	0	1992	1992	UM
Oxbow Creek	***Grand Loop Rd DS to Yell. River***	***40***	***0***	***100***	***0***	***25***	***75***	***0***	***2007***	***2008***	***MSU***
Pebble Creek	upper	25	100	0	0	100	0	0	1993	1993	UM
Pebble Creek	US of campground	30	100	0	0	100	0	0	2005	2007	IDFG
Reese Creek	above irrigation diversions	22				96	0	4	1990	1990	UM
Reese Creek	above irrigation diversions	46	60	40	0	97	0	3	2005	2007	IDFG
Rose Creek	US of Grand Loop Rd	53	15	66	19	51	>1	48	2005	2007	IDFG
Slough Creek	above cascades	25	100	0	0	100	0	0	1994	1995	UM
Slough Creek	3rd meadow	46	100	0	0	100	0	0	2002	2006	BYU
Slough Creek	1st meadow	60				88	1	11	2002	2006	BYU
Slough Creek	***3rd meadow***	***24***	***100***	***0***	***0***	***100***	***0***	***0***	***2007***	***2008***	***MSU***
Slough Creek	***canyon US of 1st meadow***	***22***	***86***	***14***	***0***	***94***	***0***	***6***	***2007***	***2008***	***MSU***
Slough Creek	***1st meadow***	***16***	***87***	***13***	***0***	***88***	***0***	***12***	***2007***	***2008***	***MSU***
Soda Butte Creek	Silver Gate	25				98	2	0	1992	1992	UM
Soda Butte Creek	US of Icebox Canyon	39				99	1	>1	2006	2007	UM
Soda Butte Creek	US of Icebox Canyon	1				50	0	50	2006	2007	UM
Stephens Creek	US of Stephens Cr Rd	13	0	58	42	31	0	69	2006	2007	IDFG
Trout Lake		***35***	***89***	***0***	***11***	***89***	***0***	***11***	***2007***	***2008***	***MSU***

*Cutthroat trout hybrid.
MSU–Montana State University, Conservation Genetics Laboratory–Steven T. Kalenowski; UM–University of Montana, Conservation Genetics Laboratory–Robb Leary; IDFG–Idaho Department of Fish and Game, Eagle Fish Genetics Lab–Matt Campbell; BYU–Brigham Young Univertsity, Genetics & Biotechnology Lab–Dennis Shiozawa.

Appendix iv. Genetic Analysis–
Westslope cutthroat trout

Water	Location (US/DS=up/downstream)	# of Samples	Individuals (%)			Allele Frequency (%)			Year Collected	Year Analyzed	Lab
			WCT	CTX*	RBT	YCT	WCT	RBT			
Black Butte Creek	***US of HWY 191***	***18***	***0***	***18***	***0***	***1***	***37***	***62***	***2007***	***2008***	***MSU***
Cougar Creek		26				6	94	0	1992	1992	UM
Cougar Creek	upper	34	50	50	0				1998	1999	UM
Cougar Creek	cabin Site	17	59	41	0				1998	1999	UM
Fan Creek: East Fork		50				2	98	0	1994	1995	UM
Fan Creek: East Fork		33	76	14	0				1997	1997	UM
Fan Creek: East Fork		31	81	19	0				1998	1999	UM
Fan Creek: East Fork		9	66	34	0	x	95	x	2002	2004	UM
Fan Creek: East Fork	upper	29	76	24	0	2	95	3	2003	2005	IDFG
Fan Creek: East Fork	lower	29	76	24	0	4	94	2	2003	2005	IDFG
Fan Creek: Main Stem		5	100	0	0	0	100	0	1997	1998	UM
Fan Creek: Main Stem	campsite WC3	31	77	23	0				1998	1999	UM
Fan Creek: Main Stem	campsite WC3	13	92	8	0				2002	2004	UM
Fan Creek: Main Stem	middle	5	40	40	20	0	67	33	2003	2005	IDFG
Fan Creek: Main Stem	upper	18	56	44	0	6	85	9	2003	2005	IDFG
Fan Creek: North Fork		51				2	98	0	1994	1995	UM
Fan Creek: North Fork		1	100	0	0	0	100	0	1997	1998	UM
Fan Creek: North Fork		35	100	0	0				1998	1999	UM
Fan Creek: North Fork		30	80	20	0	x	97	x	1999	2004	UM
Fan Creek: North Fork		18	72	18	0	x	90	x	2001	2004	UM
Fan Creek: North Fork		41	73	17	0	x	97	x	2002	2004	UM
Fan Creek: North Fork	lower	30	97	3	0	0	99	>1	2003	2005	IDFG
Fan Creek: North Fork	upper	35	97	3	0	0	99	>1	2003	2005	IDFG
Fan Creek: Trib. #501602		30				8	86	7	1993	1993	UM
Fan Creek: Trib. #501602		10	50	40	10				1998	1999	UM
Gallatin River	headwaters	16				7	79	10	1993	1993	UM
Geode Creek**	DS of Grand Loop Rd	40	100	0	0	0	100	0	2005	2007	IDFG
Geode Creek**	US & DS of Grand Loop Rd	50	100	0	0	0	100	0	2007	2007	UM
Grayling Creek	US of HWY191	27				7	82	13	1990	1991	UM
Grayling Creek		30	50	50	0				1997	1998	UM
Grayling Creek		31	56	44	0				1998	1999	UM
Grayling Creek	***US of HWY 191***	***45***	***13***	***87***	***0***	***14***	***79***	***7***	***2007***	***2008***	***MSU***
Gniess Creek		10	0	80	20				1998	1999	UM
Last Chance Creek	US of old HWY 191	80	100	0	0	0	100	0	2005	2005	IDFG
Last Chance Creek	US of old HWY 191	30	100	0	0	0	100	0	2006	2006	UM
Last Chance Creek	US of old HWY 191	20	100	0	0	0	100	0	2007	2007	UM
Last Chance Creek	***US of old HWY 191***	***21***	***100***	***0***	***0***	***0***	***100***	***0***	***2008***	***2008***	***UM***
Specimen Ck: East Fork		27				16	83	1	1994	1995	UM
Specimen Ck: East Fork		16	25	75	0				1997	1998	UM
Specimen Ck: East Fork		23	39	61	0				1998	1999	UM
Specimen Ck: North Fork		25				11	73	16	1994	1995	UM
Specimen Ck: North Fork		6	0	100	0				1997	1998	UM
Stellaria Creek		16	88	12	0				1998	1999	UM

**Geode Creek lies outside the historic range of WCT but supports a population of WCT.
X = allele frequency reported as WCT and "other."

Appendix v. Seasonal Staff, 2008

Name
Hilary Billman
Scott Brown
Stuart Brown
Tim Bywater
Angela Coleman
Erica Finley
Hallie Ladd
Nicole Legere
Derek Rupert
Jeannine Sibley
Stacey Sigler
Joe Skorupski
Bill Voigt
Chelsey Young

NPSPHOTO/C. YOUNG

Seasonal staff member Hallie Ladd and volunteer Casey Koleski clear debris from the weir on Clear Creek.

Appendix vi. Long-term Volunteers, 2008

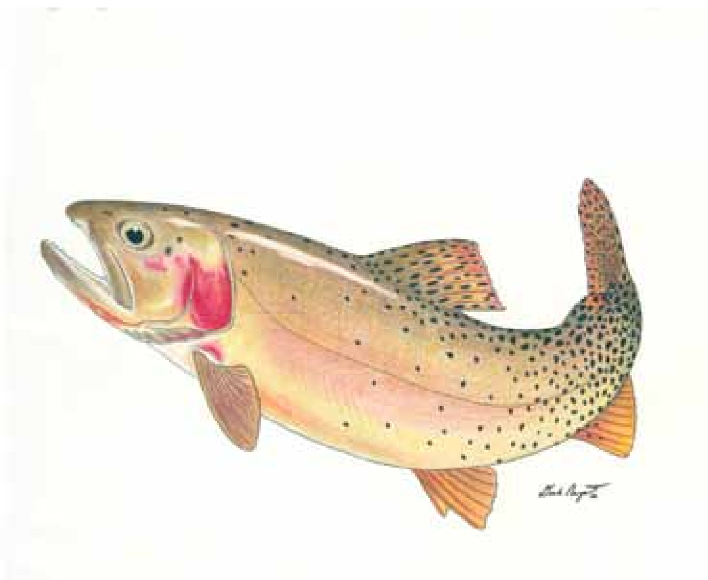
Name
Nick Bankston
Brendan Crowley
Lisa Fouladbash
Casey Koleski
Sam LaMotte
Kate Olsen
Molly Payne
Greg Schieber
Shane Scranton
Alexis Wolf
Stephanie Yager

NPSPHOTO/T. KOEL

Montana Conservation Crew and contractors place barrier logs.

NPSPHOTO/T. KOEL

NPS Corral Operations pack in supplies to East Fork Specimen Creek.



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